Before the FEDERAL COMMUNICATIONS COMMISSION Washington, DC 20554

In the Matter of)
Expanding Access to Mobile Wireless Services Onboard Aircraft) WT Docket No. 13-301
)

COMMENTS OF AEROMOBILE COMMUNICATIONS LIMITED

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February 14, 2014

SUMMARY

AeroMobile Communications Limited ("AeroMobile") appreciates the opportunity to submit comments in response to the notice of proposed rulemaking ("NPRM") in which the Federal Communications Commission ("FCC" or "Commission") seeks comment on proposed rules to facilitate the introduction of in-flight mobile connectivity ("IMC") onboard U.S.-registered aircraft and foreign-registered aircraft traversing U.S. airspace. AeroMobile strongly supports the Commission's initiative to permit IMC operations in the United States. U.S. airlines and the U.S. traveling public would benefit significantly from access to mobile broadband applications available elsewhere today.

A properly structured regulatory regime will facilitate expeditious access to existing IMC applications and promote further innovation in IMC offerings, which would expand access to mobile broadband connectivity to U.S. consumers. The *NPRM* offers a useful foundation to achieve these important objectives. As discussed herein, AeroMobile believes that the Commission should adopt an IMC regulatory regime that:

- (i) provides airlines the choice to offer IMC as an in-flight connectivity option and the flexibility to enable the specific IMC applications that best suit their passengers' needs;
- (ii) permits IMC to operate as a roaming service through partner wireless carriers, as it does today, while allowing for other possible commercial implementations;
- (iii) ensures compatibility with co-frequency systems and services through adoption of existing IMC standards, while allowing for the development of additional standards for the U.S. domestic market;
- (iv) provides expeditious access to in-flight mobile broadband connectivity to the broadest range of passengers possible; and
- (v) accounts fully for the unique international commercial aviation context in which IMC is offered.

AeroMobile respectfully suggests that the most appropriate means for the Commission to achieve these objectives is to adopt a license-exempt/unlicensed approach for IMC equipment installed and operated onboard U.S. and foreign aircraft, which is similar to the approach adopted by Ofcom in the United Kingdom and adopted in many other nations throughout the world. The Commission may also supplement this approach with Part 87 aircraft station licensing for U.S.-registered aircraft to ensure that authority to operate IMC equipment is expressly established for aircraft that travel outside the United States.

Because IMC equipment operates at very low power on an unprotected, non-interference basis pursuant to uniform technical standards, and there is no discretion to operate the equipment in any other manner (*e.g.*, at higher powers, different frequencies, etc.), such equipment is an excellent candidate for license exemption/unlicensed operation. This approach also avoids a number of complex issues that may impede the introduction of IMC in the United States, including: (i) licensing IMC operations on spectrum that may be licensed to others; (ii) licensing or re-licensing equipment installed and operated onboard foreign aircraft; (iii) developing separate service rules that may be unnecessary in the context of IMC roaming services; and (iv) authorizing IMC operations on spectrum that may not be appropriately allocated for commercial operations.

At the end of the day, this proceeding is about enabling IMC in the United States using technology that has proven to be compatible with other systems and services throughout the world after years of real-world experience; and affording U.S. airlines and foreign airlines operating in U.S. airspace the choice to offer such IMC applications to their passengers. AeroMobile believes this is possible through a license exempt/unlicensed approach and looks

forward to working with the Commission and interested parties to address fully the technical and regulatory issues associated with introduction of IMC in the United States.

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AeroMobile Communications Limited ("AeroMobile") respectfully submits these comments in response to the Notice of Proposed Rulemaking ("NPRM") in which the Federal Communications Commission ("FCC" or "Commission") seeks comment on revising its rules to facilitate the introduction of in-flight mobile connectivity ("IMC") onboard U.S.-registered aircraft and foreign-registered aircraft traversing U.S. airspace. Specifically, the FCC proposes to eliminate existing restrictions on in-flight use of mobile devices and adopted new rules that permit aircraft operators to offer IMC applications via airborne access systems ("AASs") designed to ensure compatibility with co-frequency systems and services.

AeroMobile strongly supports the Commission's initiative to permit IMC operations in the United States. U.S. airlines and the traveling public would benefit from access to mobile broadband applications available elsewhere today, and foreign airlines, which serve many U.S. passengers, would no longer have to suspend IMC operations upon entering U.S. airspace. The Commission can achieve these important objectives while protecting other systems and services

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¹ In the Matter of Expanding Access to Mobile Wireless Services Onboard Aircraft, WT Docket No. 13-301, Notice of Proposed Rulemaking, FCC 13-157 (rel. Dec. 13, 2013) ("NPRM").,

from harmful interference and improving the spectrum environment for terrestrial wireless networks.

I. INTRODUCTION

AeroMobile, a U.K.-based company jointly owned by Panasonic Avionics Corporation and the Telenor Group, has developed technology that enables aircraft passengers and crew to use their own mobile devices for voice, text and data applications while in flight. AeroMobile's onboard IMC system connects mobile devices within the aircraft cabin to the aircraft's off-board communications link using a low power picocell and prevents interference from onboard mobile devices to terrestrial networks through a range of radiofrequency management techniques.

AeroMobile's IMC solution currently operates on a large and increasing number of commercial aircraft throughout Europe, Asia, Africa, the Middle East, Oceania and the Americas pursuant to harmonized global standards; and has been certified by the Federal Aviation Administration ("FAA") and the European Aviation Safety Agency ("EASA") for use on U.S. and European aircraft, respectively. However, AeroMobile's IMC solution is currently not offered by U.S. airlines, and IMC operations are suspended onboard equipped foreign aircraft while traversing U.S. airspace.

AeroMobile has extensive experience with communications and aviation regulatory issues supporting IMC operations around the world and appreciates the foundation laid by the Commission in the *NPRM*. The general approach and many principles proposed in the *NPRM* provide a useful foundation to build a comprehensive IMC regulatory regime; and the record developed in this proceeding, including review of the authorization approaches of countries and technical standards adopted to facilitate IMC operations, will permit expeditious adoption of rules governing IMC in the United States.

II. BACKGROUND

In examining technical and regulatory approaches to facilitate IMC in the United States, it is important to consider current the commercial and operational implementation of IMC offerings. Current IMC implementations, including existing international standards and the roles of various IMC participants, have informed global regulatory approaches and should help guide decision-making in the United States.

The Commission has a unique opportunity to expeditiously bring the benefits of IMC to U.S. airlines and the public based on years of operational experience with IMC internationally. While adopted rules should not constrain the development of alternative IMC approaches, the Commission should consider existing IMC operational approaches when developing a U.S. regulatory regime. Moreover, while the FCC must address U.S.-specific issues, it should also take advantage of work done in other jurisdictions to the extent they relate to spectrum and equipment that can be used for IMC in U.S. airspace.

A. IMC Commercial Implementation

In the *NPRM*, the Commission appropriately focuses on the regulatory authority necessary to provide the link between the onboard IMC equipment and a passenger's mobile device.² Review of existing IMC commercial implementation and the authority held by IMC participants is informative in deciding the appropriate treatment of the onboard link.

1. The Roles of IMC Participants

The ability to provide access to IMC applications to airline passengers involves the consent and participation of a number of parties including airlines, IMC providers, off-board link

² NPRM at \P 40.

and terrestrial backhaul providers and terrestrial wireless carriers. Although each entity's role in delivering IMC to end-user passengers varies, each role is essential to the process.

Airlines. Airlines seek to enhance the passenger experience by allowing them to use mobile devices to connect seamlessly to onboard mobile broadband applications just as they would on the ground. Airlines acquire IMC equipment from manufactures and determine which IMC applications (*i.e.*, data, SMS, voice, or a combination thereof) to make available to passengers. Consistent with aviation safety principles, an airline (specifically, the pilot in command of an aircraft) has ultimate control over IMC equipment onboard its aircraft, but the airline does not directly participate in the provision of IMC applications to passengers.

IMC Providers. IMC providers install IMC equipment on customer airlines and integrate the equipment with off-board communications links and the terrestrial backhaul provided by other providers. Through roaming agreements with terrestrial wireless carriers, IMC providers enable passenger access to onboard IMC equipment. Thus, IMC providers integrate onboard equipment with connections to the terrestrial network and, through the roaming agreement, provide integrated mobile connectivity offerings to wireless carriers on a wholesale basis for resale to their customers.

Off-board Link and Terrestrial Backhaul Providers. Off-board link providers, which may be terrestrial or satellite-based, provide a separately authorized link between the aircraft and the terrestrial network. Terrestrial backhaul providers route mobile traffic on the terrestrial network pursuant to their existing authority. IMC providers contract with off-board link and terrestrial backhaul providers to carry IMC traffic across and within the terrestrial network.

Terrestrial Wireless Carriers. Passengers can only use their own mobile devices to access IMC applications if their home wireless carrier has an executed roaming agreement with

the IMC provider. Through this contract, IMC providers provide wholesale access to terrestrial wireless carriers who, in turn, offer IMC applications on a retail basis (as a roaming service) to their subscribers onboard an IMC-equipped aircraft. Wireless carriers authorize subscriber devices to access the IMC network, set prices for the IMC applications, invoice their subscribers for IMC usage, and otherwise maintain the direct carrier-customer relationship. The IMC provider is paid by the wireless carrier for services accessed by its subscribers at wholesale rates established in the roaming agreement.

2. IMC Is a Roaming Service

The key differentiator between IMC and Wi-Fi-based in-flight connectivity offerings is the passengers' ability to access mobile broadband applications seamlessly using their own mobile device just as if they were roaming overseas. A passenger's home wireless carrier offers IMC applications as a roaming service to their consumers and consumer use of the mobile device using IMC can only occur with the express consent of the carrier. Although other commercial approaches may be possible for the U.S. domestic market, the FCC should accommodate the roaming nature of current IMC offerings.

It is also important to note that, like global mobile-satellite service ("MSS") networks, both existing global IMC networks (AeroMobile and OnAir) are designated as non-geographic international networks for ITU number and traffic routing purposes. Thus, connecting to onboard IMC equipment is akin to roaming onto a single international network regardless of the geographic location of the aircraft.³

³ The international roaming nature of IMC networks, as well as limited U.S. participation in IMC standards development, also helps explain the reliance on international spectrum allocations for in-cabin service links.

B. IMC Technical Implementation

IMC technical implementation is predicated on two basic concepts: (i) controlling mobile device power to the lowest level possible and communicating on specified frequencies within the aircraft cabin; and (ii) shielding mobile devices from pilot signals of terrestrial base stations to prevent them from connecting to the terrestrial network at high transmit powers. These functions are performed by a low-power picocell and network control unit ("NCU"), respectively, which together comprise the onboard AAS equipment.

The picocell communicates with onboard mobile devices on specified frequency bands and commands associated mobile devices to a low power state so there are not able to transmit at higher power.⁴ Consistent with the original technical standard governing IMC operations, the first-generation picocell on IMC systems operates in the 1800 MHz band using GSM technology. AeroMobile's next generation picocell, which U.S. airlines would likely use for implementation, is designed to communicate in the 1800 MHz and 2100 MHz bands using GSM, UMTS and LTE technologies in accordance with recently updated IMC standards.⁵ The incorporation of LTE technology will afford non-GSM carrier customers in the United States to access IMC applications.

The NCU is designed to emit a low level signal to raise the noise floor of mobile devices receiver within the aircraft cabin used in the country in which an equipped aircraft is flying over

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⁴ If for some reason the power level proves insufficient to connect to the onboard network, then the link will be dropped.

⁵ Report from CEPT to the European Commission in response to the Second Mandate to CEPT on mobile communication services on board aircraft (MCA), CEPT Report 48 (Mar. 8, 2013), *available at*:http://www.erodocdb.dk/Docs/doc98/official/pdf/CEPTREP048.PDF ("CEPT Report 48").

at that time. In this way, the NCU masks the pilot signal transmitted by terrestrial base stations and prevents onboard mobile devices from attempting to connect to terrestrial wireless networks at high transmit powers. AeroMobile's first generation NCU can dynamically adjust to transmit on relevant spectrum bands around the world, and its next generation NCU is designed to be even more flexible to address new mobile spectrum bands as they are brought into use in the future.

The attached Technical Appendix provides additional information regarding the technical characteristics of AeroMobile's AAS equipment (which reflect existing international standards) and interference assessments that demonstrate the IMC can operate successfully in U.S. airspace without causing interference to other systems and services. AeroMobile looks forward to reviewing this information, as well as other technical data submitted in the record of this proceeding, with the Commission and interested parties to facilitate a common understanding of the potential impact of IMC operations using existing and next-generation AAS equipment – the only equipment that will be available to support IMC for the foreseeable future.

III. IMPLEMENTATION OF IMC IN THE UNITED STATES WOULD STRONGLY SERVE THE PUBLIC INTEREST

AeroMobile agrees with the Commission that authorizing IMC on U.S. and foreign airlines will promote the public interest by expanding consumer access to mobile broadband applications.⁶ Airlines and passengers have experienced significant benefits from the expansion of in-flight connectivity options, including increased passenger satisfaction resulting from additional entertainment options and the ability to remain connected to family, friends and work

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⁶ NPRM at \P 3.

colleagues while in transit.⁷ The introduction of IMC enhances competition in in-flight connectivity and affords airline passengers additional means to remain connected.

The Commission seeks to facilitate the efficient and flexible use of spectrum resources in the context of broadband wireless access and other services. Extensive technical studies and years of real-world operating experience confirm that IMC can be provided on an unprotected, non-interference basis in bands shared with commercial and government users alike. Indeed, by employing AASs, the reach of mobile broadband applications can be extended to the aircraft cabin without the need for additional or exclusive spectrum allocations. As a result, IMC operations represent an efficient and flexible use of spectrum.

Moreover, IMC systems actually *improve* the operational environment for terrestrial wireless networks. Today, large numbers of mobile devices remain inadvertently powered-on while onboard commercial aircraft and transmit at high powers in an effort to connect to terrestrial base stations. By controlling the transmissions of onboard mobile devices to their lowest power state and shielding mobile devices from receiving terrestrial base station signal, IMC systems reduce the interference caused by uncontrolled mobile device transmissions.

IMC operations are also consistent with the traditional carrier-customer relationship and do not affect a carrier's control over associated mobile devices. A passenger's mobile device will only connect to an IMC system if the carrier has affirmatively consented through a roaming agreement and, even then, the carrier maintains control over retail pricing, invoicing, and other aspects of the traditional carrier-customer relationship.

Given these and other important public benefits, including the opportunity for U.S. airlines to offer IMC applications already offered by their competitors, the FCC should allow

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⁷ *Id.* at ¶¶ 16-17.

airlines to further enhance the experience of U.S. passengers by implementing IMC in the United States.

IV. THE NPRM PROVIDES THE FOUNDATION FOR A COMPREHENSIVE IMC REGULATORY REGIME

AeroMobile commends the Commission for its initiative to expand the reach of mobile broadband into the aircraft cabin and for the comprehensive nature of the issues considered in the IMC regulatory regime proposed in the *NPRM*. As discussed in the following sections, AeroMobile believes that the Commission should adopt an IMC regulatory regime that:

- (i) provides airlines the choice to offer IMC as an in-flight connectivity option and the flexibility to enable the specific IMC applications that best suit their passengers' needs;
- (ii) permits IMC to operate as a roaming service through partner wireless carriers as it does today, while allowing for other possible commercial implementations;
- (iii) ensures compatibility with co-frequency systems and services through adoption of existing IMC standards, while allowing for the development of additional standards for the domestic market;
- (iv) provides expeditious access to in-flight mobile broadband connectivity to the broadest range of passengers possible; and
- (v) accounts fully for the unique context of international commercial aviation in which IMC is offered.

AeroMobile believes that the Commission appropriately looks to the Ofcom model in the United Kingdom as a basis for implementation of IMC in the United States. However, the FCC should take additional developments beyond those cited in the *NPRM* including a new Ofcom consultation on IMC that commenced just this week, into account.

A. The Commission Should Authorize AAS Operations Under a License Exempt/Unlicensed Approach and Only, If Necessary, Issue Part 87 Licenses to U.S. Aircraft Operators

In the *NPRM*, the Commission proposes to revise its rules to permit AASs to operate onboard U.S. and foreign-registered aircraft to provide IMC pursuant to Part 87 aircraft station

licenses.⁸ The FCC bases its proposal, in part, on similar approaches to enable IMC that includes aircraft station licensing adopted elsewhere in the world, including by Ofcom in the United Kingdom. However, as indicated in an Ofcom consultation commenced earlier this week to update its rules governing IMC (known as mobile communications onboard aircraft or "MCA" in Europe), aircraft station licensing for U.K.-registered aircraft is only one element of the comprehensive regulatory regime adopted to enable IMC in the United Kingdom and elsewhere.

Specifically, Ofcom is updating its regulations to implement the new IMC technical standard adding the 2100 MHz band for in-cabin service links and other updated technical requirement. Preview of the Ofcom consultation document and underlying materials confirms that its IMC regulatory regime includes: (i) license exemption under the U.K. Wireless Telegraphy Act for AAS operations in the United Kingdom onboard U.K. and foreign-registered aircraft, subject to compliance with applicable international standards; (ii) aircraft station licensing (notice of variation) to authorize AAS operations onboard U.K.-registered aircraft flying outside the United Kingdom; and (iii) mutual recognition of foreign IMC licensing, subject to compliance with applicable international standards. This approach is consistent with implementing regulations adopted after its the decision to permit IMC operations in 2008. 10

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⁸ *NPRM* at ¶¶ 43-47.

⁹ See Ofcom, Notice of Proposal to make the Wireless Telegraphy (Mobile Communications Services on Aircraft) (Exemption) Regulations 2014 (Feb. 11, 2014) available at: http://stakeholders.ofcom.org.uk/binaries/consultations/mca-exemption/summary/FINAL_MCA_Notice.pdf ("MCA Consultation").

¹⁰ See 2008 No. 2427, The Wireless Telegraphy (Mobile Communication Services on Aircraft) (Exemption) Regulations 2008, (entered into force Oct. 1, 2008) ("MCA Exemption Regulations").

License exemption, however, for AASs would be more appropriate as a regulatory basis. The equipment is designed to operate at very low power on an unprotected, non-interference basis pursuant to a uniform technical standard applicable in every jurisdiction that permits IMC. The Commission should consider adopting this type of approach in the United States, either through formal license exemption subject to compliance with applicable technical requirements or through adoption of AAS technical rules in a new subpart of Part 15 (Radio Frequency Devices) to facilitate unlicensed operations. As discussed below, adoption of AAS technical rules to govern all license-exempt/unlicensed IMC operation on U.S. and foreign aircraft would facilitate the introduction of IMC in the United States, even if the FCC concludes that Part 87 licensing is appropriate for U.S.-registered aircraft traveling outside the United States.

1. The Commission Should Ensure that AAS Technical Rules Can Be Applied Uniformly

After appropriate review and validation of IMC technical standards, the Commission must decide where to incorporate such standards in its rules. Regardless of where such rules are incorporated, the Commission should ensure that AAS standards facilitate IMC operations on U.S. and foreign aircraft in the United States and on U.S. aircraft traveling abroad.

As discussed above, other countries treat AAS equipment as license exempt subject to compliance with applicable technical standards. This is possible because, like the Wi-Fi access points used for in-flight Internet connectivity, AAS equipment produces very low power transmissions within the aircraft pursuant to a uniform technical standard. There is no operator discretion or potential interference to other services associated with operating the equipment that

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¹¹ See Communications on board Aircraft, Ofcom Statement on Authorising MCA Services (Mar. 26, 2008) ("MCA Decision").

might suggest individual licensing is necessary, even though an aircraft operator maintains ultimate control of the equipment (as it does with the onboard Wi-Fi access point).

Adoption of generally applicable technical rules — whether through an exemption decision or incorporation into its unlicensed device rules — would ensure compliance with such requirements on U.S. and foreign aircraft without the need for individual licensing. Not only does this approach further the interests of administrative convenience and conservation of scarce administrative resources by avoiding ongoing licensing decisions, the Commission can be assured of compliance with applicable standards because AAS equipment is manufactured, tested and certified for compliance in the context of civil aviation certification, and there is no possibility of operating the equipment in a non-compliant manner.

In fact, because AAS equipment is certified for compliance with applicable standards under comprehensive civil aviation certification, which is even more comprehensive than the Commission's own equipment authorization and verification procedures embodied in Part 2 of the rules, it may be possible for the Commission to forbear from application of Part 2 requirements in these unique circumstances. This would avoid duplicative certification efforts before both the FAA and FCC. To the extent that Part 2 equipment authorization and verification is required, the Commission should permit AAS equipment providers such as AeroMobile, to satisfy such requirements on behalf of all partner airlines.

A license exemption/unlicensed approach would allow the Commission to avoid potential infirmities with Part 87 licensing or even a license by rule approach. For example, it is not entirely clear that aircraft equipment that does not use designated aeronautical bands is appropriate for Part 87 licensing or that the Commission may issue such licenses for equipment installed and operated onboard foreign aircraft. Moreover, statutory limitations may restrict the

ability to rely on a license by rule approach. Although it may be possible to correct such issues via appropriate rule modifications, adopting generally applicable AAS rules could avoid such issues entirely.

Operation of AAS equipment pursuant to a license exempt/unlicensed approach would avoid the uncertainties associated with formal licensing (or adopting a license by rule) on spectrum that may be licensed to others. If the FCC allows IMC based on a license-exempt or unlicensed basis on an unprotected, non-interference basis only, the Commission would confirm existing licensees' rights to their spectrum.

Furthermore, such an approach will facilitate use of frequencies that have not otherwise been allocated for commercial use but can be used for low-power AAS operations, including the existing 1800 MHz service link band upon which current IMC systems are based. In contrast, Part 87 licensing or licensing by rule presumably would require an allocation to commercial service that could substantial delay the introduction of IMC and deprive U.S. consumers of inflight mobile broadband applications that are available elsewhere today.

Finally, such a license-exempt/unlicensed approach would be consistent with recent Commission precedent. Less than a month ago, the Commission released an order adopting new Part 15 rules for tank level probing radars ("LPRs"). The *LPR Order* also involves devices operating under unique circumstances with transmit power levels towards potential victim receivers akin to Part 15 levels, but do not technically comply with the FCC's unlicensed device rules. In that decision, AeroMobile understands that the Commission may have originally considered licensing such equipment by rule but ultimately adopted a new section in Part 15 to

¹² Amendment of Part 15 of the Commission's Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz, Report and Order and Order, ET Dockets 10-23 and 10-27 (rel. Jan. 15, 2014) ("LPR Order").

permit unlicensed LPR operation because, although they operate at higher power than other Part 15 unlicensed devices, the power is directed into a tank for measurement purposes and the energy outside the tank (which could potentially affect co-frequency operations) is similar to Part 15 unlicensed device levels. Similarly, AAS operations are confined to the aircraft cabin flying at altitudes of 3,000 meters or higher and comply with Part 15 levels at approximately 275 meters from the aircraft, and thus far away from any potential victim receivers.

Given the low-power nature and unique characteristics of LPR transmissions, the Commission adopted new Part 15 Rules to accommodate this technology and even adopted ECC and CEPT standards in the absence of U.S. domestic standards for LPR operations.¹³ AeroMobile suggest the Commission may adopt a similar approach through an exemption decision or new Part 15 subpart for AAS equipment. AeroMobile would also note that it is the characteristics of the equipment, rather than the applications carried over the equipment, that should guide the Commission's decision on the optimum regulatory regime to authorize AAS operations. Gogo LLC's new text and voice capabilities over Wi-Fi underscore the need for the FCC's in-flight connectivity equipment authorization regime to be service agnostic and, in the interest of promoting innovation and competition, focus on the characteristics of the equipment itself.¹⁴

Accordingly, it appears that the Commission's objectives can be best realized and the public most efficiently served by adopting a license exempt/unlicensed approach to AAS operations in the United States. In this way, the Commission can ensure uniform compliance

¹³ LPR Order at ¶ 11.

¹⁴ See http://www.aircell.com/gogotexttalk.

with technical requirements, minimize the administrative burden of the IMC regulatory regime, and further other important public policy objectives.

2. The Commission May Supplement Generally Applicable Rules with Part 87 Licensing for U.S.-Registered Aircraft, if Necessary

The *NPRM* correctly notes that in an analogous regulatory construct, Ofcom issues a 'notice of variation" (akin to an FCC Part 87 aircraft station license) for U.K.-registered aircraft implementing IMC. Although AAS equipment operations are license exempt in the United Kingdom, the notice of variation establishes that the aircraft operator has authority to operate the AAS equipment outside the United Kingdom. Thus, the notice of variation constitutes operating authority from the aircraft's registering nation that may be recognized by overflown countries pursuant to generally accepted principles of international aviation law. Consistent with those same principles and with the general exemption for AAS operations in the United Kingdom, Ofcom does not license AAS operations onboard foreign aircraft traversing U.K. airspace.

The Commission may seek to pursue Part 87 licensing of AAS equipment as proposed in the *NPRM* if it would further the interests of ensuring U.S. airlines have clear authority to operate AAS equipment while traversing international or foreign airspace. However, AeroMobile would note that it is not clear that Part 87 authority is required in the unique context of in-flight connectivity. Importantly, for aircraft equipment used for in-flight connectivity that does not utilize designated aeronautical spectrum (like Ku-band and Ka-band aircraft earth station terminals, 800 MHz air-ground equipment and Wi-Fi access points onboard the aircraft), ¹⁵ it does not appear that Part 87 licensing is required for operations outside the United

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¹⁵ See 47 C.F.R. §§ 22.925, 25.227; NPRM at ¶¶ 16-19, FN52-62.

States.¹⁶ Thus, the Commission presumably could rely on authority granted on any rule part to support in-flight connectivity equipment operations outside the United States.

B. The Commission Need Not Adopt Separate Service Rules for IMC Operations

As the Commission is aware, although airlines install and operate AAS equipment to support IMC offerings to their passengers, they are not involved in the delivery of IMC applications to the end users. Instead, the IMC provider and the passenger's home wireless carrier together are responsible for delivering in-flight mobile broadband applications. Thus, there is no basis to impose service requirements on the aircraft operator of AAS equipment.

Indeed, the Ofcom MCA Decision, cited by the Commission as a principal example of IMC licensing, acknowledges that U.K. aircraft station operators are primarily responsible for operating the equipment onboard the aircraft and IMC providers are more responsible for compliance with the general conditions applicable to provision of electronic communications services onboard the aircraft.¹⁷ In other words, the general conditions for service provision referenced by Ofcom are imposed by separate statute generally applicable to electronic communications service providers, including the IMC provider and the passenger's home wireless carrier.

¹⁶ Furthermore, it is not clear that Part 87 applies to IMC because that rule part appears designed for critical aviation services related to the "operation of aircraft" (47 C.F.R. § 87.5), and aircraft stations are used primarily for "the necessities of safe, efficient, and economic operation of aircraft" (47 C.F.R. § 87.185). Although Part 87 does acknowledge the potential for "public correspondence" to be provided using designated aeronautical spectrum, the frequencies used for IMC and the off-board link are designated for mobile, MSS or FSS use rather than aeronautical use. *Compare* 47 C.F.R. §§ 22.925; *NPRM* at ¶¶ 16-19, FN 52-62 *with* 47 C.F.R. §§ 87.131, 87.133, 87.169, 87.173.

¹⁷ MCA Decision at 16, 17.

Although the Commission does not have overarching service rules that may be applicable to IMC operations, the wholesale roaming nature of IMC means there is always a licensed carrier involved with licensed carrier-related obligations – the passengers home wireless carrier – even if the mobile broadband applications provided would not be considered common carrier services.

Since the passenger's home wireless carrier permits access through a roaming agreement, sets retail pricing, bills the customer and otherwise maintains the carrier-customer relationship, the Commission can reasonably rely on the existing carrier licensing to cover any "service" authority – particularly since IMC simply extends the reach of mobile broadband capabilities into the aircraft cabin using the passenger's carrier-provided mobile device. Moreover, the participation of carriers ensures that other important carrier-related obligations can be met.

Moreover, AeroMobile suggests that the Commission should avoid imposing separate service obligations on a nascent IMC market that has not even begun to develop in the United States. As noted by Ofcom in the MCA Decision, there is no indication that this developing industry requires regulatory intervention (*e.g.*, with respect to retail access charges)¹⁸ and nothing has changed to alter that conclusion. Current IMC commercial implementation, utilization trends and actual customer experience suggests that no prescriptive service regulation is necessary. To the extent that additional technical standards or business models may be useful to support greater access to IMC applications, the Commission should rely on industry to develop such approaches rather than on unnecessary regulations that could stifle innovation and competition.

¹⁸ MCA Decision at 20.

Finally, if the Commission adopts IMC service regulations, the application of such rules should be limited to U.S. airlines only. The Commission should avoid "reaching into" the foreign aircraft cabin to impose service requirements on foreign airlines. Like other services provided onboard an aircraft, IMC is subject to the primary jurisdiction of the airline's registering nation. Imposition of potentially conflicting service requirements would infringe on the regulatory authority of a foreign airline's registering nation and invite other countries to impose intrusive regulation on IMC and other in-flight connectivity offerings onboard U.S. aircraft traveling abroad.

V. THE COMMISSION SHOULD ADOPT A LICENSE EXEMPT/UNLICENSED APPROACH IN ITS COMPREHENSIVE IMC REGULATORY REGIME

As discussed above, AeroMobile respectfully submits that a license exempt/unlicensed approach, potentially combined with Part 87 licensing for U.S.-registered aircraft, would be the most efficient and effective means for the Commission to facilitate the expeditious delivery of in-flight mobile broadband applications to U.S. consumers. Regardless of the structure ultimately adopted, however, the Commission should consider the following additional elements in implementing a comprehensive IMC regulatory regime.

A. The Commission Should Validate and Adopt Existing IMC Standards To Hasten the Benefits of IMC for U.S. Consumers

As the Commission is aware, IMC applications have been available on foreign aircraft for years with AASs operating pursuant to technical standards designed to ensure compatibility with disparate terrestrial systems and services around the world. These standards, which are based on limiting the transmit power of onboard equipment and mobile devices to very low levels and prevent onboard mobile devices from connecting directly to the terrestrial network, prevent emissions onboard IMC-equipped aircraft from causing interference to other systems and services, including those in the United States. Compatibility studies between IMC and other

services were conducted for 450 MHz CDMA450, FlashOFDM; 800 MHz LTE; 900 MHz GSM, UMTS, LTE, WiMAX; 1800 MHz GSM, UMTS, LTE, WiMAX; 2100 MHz FDD UMTS, LTE; 2600 MHz FDD UMTS, LTE, RAS (2655-2690 MHz); 2600 MHz TDD UMTS, WiMAX, LTE, RAS (2655-2690 MHz); Radioastronomy service (RAS) (2690-2700 MHz); and Radars (2700-2900 MHz).¹⁹

The same basic principle holds true with these assessments and future analyses: The power density outside the aircraft produced by IMC operations, including AAS equipment and mobile device transmissions, is akin to Part 15 unlicensed device levels. Part 15 power levels are met at a distance of approximately 275 meters from the aircraft -- aircraft that are flying at high altitudes (although the minimum altitude for operations is 10,000 feet, aircraft cruise at approximately 30,000 feet for the majority of their flight) with large separation distances and at speeds of 500 mph. Thus, the impact of IMC operations would be substantially less than that of Part 15 unlicensed devices that are currently permitted to operate in the United States in all of the bands used by IMC systems and associated mobile devices. The Commission can rely on these studies, and supplemental information for additional frequency bands, to adopt existing IMC technical requirements to protect other systems and services.

AeroMobile would also note that the existing technical studies are extremely conservative in their approach. For example, the assumptions for transmission level from IMC-equipped aircraft assume worst-case position of a mobile relative to a victim receiver (angle to the ground) and do not account for aircraft motion, whereby an equipped aircraft is actually at

¹⁹ See ECC Decision of 1st December 2006 on the harmonised use of airborne GSM systems in the frequency bands 1710-1785 and 1805-1880 MHz, ECC/DEC/(06)07 (amended Mar. 13, 2009), available at: http://www.erodocdb.dk/Docs/doc98/Official/Pdf/ECCDec0607.pdf (ECC Decision).; ECC Report 187 Compatibility study between mobile communications services onboard aircraft (MCA) and Ground based systems - January 2013; CEPT Report 48.

the worst case position only momentarily and otherwise is flying rapidly towards or away from that position (and thus more typically in the much lower sidelobes of the victim antenna). Thus, among other things, the fleeting nature of potential interference resulting from the speed of the aircraft support the extremely conservative nature of existing analyses and reliance on these analyses in considering the potential impact of IMC in the United States.

The Commission and interested parties should focus their efforts on expedited review of existing technical studies and supplemental analysis to determine whether current IMC standards can support IMC operation on U.S. and foreign aircraft in the Unites States. In this way, the Commission can expeditiously adopt IMC standards to hasten the introduction of IMC for U.S. consumers. AeroMobile believes that these existing standards are more than adequate to permit IMC operations onboard U.S. aircraft and to permit foreign airlines to continue IMC operations while traversing U.S. airspace.

B. Adopting Existing IMC Standards Will Protect U.S. Systems and Services and Further Other Important Policy Objectives

Current and next-generation AASs are designed and operate pursuant to existing international standards and ensure compatibility with co-frequency users. CEPT Report 48, as well as underlying studies and related standards, constitute a solid foundation on which the Commission can adopt IMC technical requirements. Because these studies and standards address a wide range of frequencies and services, any differences between the European and U.S. commercial mobile spectrum bands would not affect the relevant CEPT findings. Moreover, frequency adjustments can be made to supplement existing studies without changing the underlying analytical approaches, providing an efficient means to address systems and services that have not otherwise been addressed. The Technical Appendix attached hereto provides additional technical analysis regarding AAS operations in the United States.

The Commission's adoption of well-proven technical standards would benefit the public interest by facilitating the rapid implementation of IMC in the United States, accelerating the introduction of IMC onboard U.S. airlines with existing equipment, and promoting international harmonization for IMC operations onboard U.S. aircraft traveling internationally and foreign aircraft traveling in the United States.

Furthermore, most "smart" devices used for mobile broadband applications include the frequencies and international roaming features necessary to access current IMC systems pursuant to existing technical standards. Thus, while additional standards may be appropriate for the U.S. domestic market, the Commission should not deprive U.S. consumers of existing IMC offerings during the pendency of such standards development work.

1. Mobile Device Requirements

The Commission should adopt the specific aggregate EIRP limits outside the aircraft for mobile devices transmitting within the aircraft cabin to reflect the current values from CEPT Report 48. Because existing and next-generation picocells will operate with mobile devices on 1800 MHz and 2100 MHz frequencies only, there is no basis to adopt values for additional frequencies at this time. However, these limitations certainly could be adjusted to account for changes in free space loss for mobile device operation on U.S. spectrum or different technologies.²⁰

It is also unnecessary and impractical to limit the number of mobile devices in operation in order to protect terrestrial systems from harmful interference,²¹ because, for GSM and LTE, each device is either given a timeslot or frequency, respectively. The only technology that uses

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²⁰ See NPRM at \P 35.

²¹ See id.

the same frequency is UMTS, and this is limited to 20 devices to achieve AAS operations at 3000 meters. Of course, AASs are already designed to limit the maximum transmit power of individual mobile units to their lowest power state because of the short distances involved in the aircraft cabin. Accordingly, it is not possible for the device transmit at higher powers when connected to the onboard AAS.

2. Picocell Requirements

The Commission also should adopt the same levels specified in CEPT Report 48 for picocell operations onboard the aircraft. Again, because existing and next-generation picocells will operate with mobile devices on 1800 MHz and 2100 MHz frequencies only, there is no basis to adopt values for additional frequencies at this time. However, the Commission could allow picocells to transmit using additional mobile technologies on the foregoing bands, or add permissible bands for future use. Updated technical studies would be required to support such additions.

3. NCU Requirements

The Commission should also adopt the EIRP limits outside the aircraft from NCU transmissions as specified in CEPT Report 48. These values can be applied for the existing spectrum ranges, and can be adjusted to reflect allocation differences in U.S. mobile bands. The technical information included in the attached Technical Appendix establishes that the adjustments necessary would be relatively small. However, AeroMobile is not proposing that the Commission adopt specific levels in other bands at this time.

Importantly, the AAS is aware of the jurisdiction in which the aircraft is located and will activate available NCU frequencies only if terrestrial base stations may be operating on those frequencies in that country. Thus, the NCU would not operate in the 1800 MHz band in the

United States because there are no terrestrial base stations transmitting pilot signals that could be received by onboard mobile devices.

AeroMobile notes that the mobile bands utilized in various countries have changed over time and are expected to change in the future as new spectrum is made available for broadband mobile applications. Indeed, international IMC standards were recently updated to reflect additional service link and control bands. To account for such changes, AeroMobile has developed a next-generation programmable NCU that can dynamically adjust for control bands from 400 MHz to 4 GHz. While certain legacy AAS systems cover most control bands, they do not have the full range of dynamic capabilities of the new NCU. In view of this normal generational evolution of equipment, the Commission should ensure that any rules developed should accommodate for variations in existing and future AAS generations.

C. The Commission Should Allow for the Development of Additional IMC Standards for the U.S. Domestic Market

The most expeditious route to introducing IMC in the United States is to adopt existing international standards for which equipment is available and mutual recognition by other countries can be assured. However, the Commission and interested parties may also seek to develop additional standards that may be more geared to the U.S. domestic market. Interested parties may seek to explore additional service link spectrum or new business models that are not based on international roaming concepts as existing offerings are today.

Indeed, any regulatory regime adopted by the Commission should not be considered the end of the matter because adjustments may need to be made over time to reflect additional mobile bands that come online, new transmission technologies and other developments. Thus, as in Europe with the recent addition of the 2100 MHz service link band, modification of governing is both expected and desirable.

Development and implementation of additional U.S.-specific standards will take considerable time given the extensive technical and regulatory work the must be conducted for both telecommunications and civil aviation purposes. In the meantime, such work should not be permitted to delay the adoption of existing standards and unnecessarily deprive U.S. consumers of the benefits of new mobile broadband applications.

D. The Commission Should Include Important International Considerations in a Comprehensive IMC Regulatory Regime

The *NPRM* raises a number of important issues associated with the implementation of IMC in the United States, including many which would affect foreign airlines operating in U.S. airspace. Specifically, the Commission proposed to license AAS equipment under Part 87 of its rules to aircraft operators,²² including foreign airlines, and presumably to apply technical and service rules similarly to both U.S. and foreign aircraft operators.

AeroMobile believes that, regardless of the authorization framework adopted for U.S. airlines, the Commission should permit AAS equipment onboard foreign-registered aircraft to operate in U.S. airspace pursuant to licenses issued by the aircraft's registering nation, subject to compliance with FCC technical rules designed to prevent harmful interference.

1. The Commission Should Not Impose Duplicative Aircraft Radio Station Licensing for AAS Equipment Onboard Foreign Aircraft

Pursuant to generally accepted legal principles in international civil aviation, as well as treaty provisions in the Chicago Convention and ITU Radio Regulations, an aircraft's registering nation has primary jurisdiction to license equipment onboard the aircraft. Section 87.191 of the Commission's rules recognizes this fundamental principle.²³ Although radio equipment onboard

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²² See NPRM at ¶¶ 42-47.

²³ See 47 C.F.R. § 87.191.

foreign aircraft must operate in compliance with the regulations of overflown nations, including the potential need for supplemental operating authority, it is not at all clear that the Commission has the legal jurisdiction to independently issue aircraft station license for equipment onboard foreign aircraft – or that the Commission can or should exercise such jurisdiction (assuming it exists) under applicable principles of international law.

In view of the foregoing, the basis for the Commission's proposal to issue duplicative aircraft station licenses under Part 87 to foreign airlines seeking to operate IMC equipment in U.S. airspace is unclear. Although the Commission has the authority to condition the operation of radio equipment onboard foreign aircraft and such equipment certainly must be operated consistent with the regulatory requirement of overflown nations (*e.g.*, to avoid harmful interference), this is quite distinct from actually issuing another aircraft station license for the equipment onboard a foreign aircraft that has already been licensed by the aircraft's registering nation. AeroMobile believes that this proposed approach to enabling IMC onboard foreign aircraft is inconsistent with basic legal principles in international civil aviation, treaty provisions and with the Commission's own rules.

In the context of in-flight Wi-Fi connectivity, which has been largely led by U.S. providers and employed by many U.S. airlines, duplicative equipment license requirements for foreign aircraft could set a dangerous precedent for other countries which could adversely affect the ability of all to offer in-flight connectivity on a global basis. The suggested license exempt/unlicensed approach avoids the potential adverse consequences of additional equipment licensing and recognizes foreign aircraft radio licensing, subject to compliance with applicable IMC requirements. In this way, the Commission will ensure that IMC equipment onboard

foreign aircraft complies with U.S. regulations without infringing on the jurisdiction of foreign administrations.

Finally, if the Commission adopts service-related obligations for IMC operations onboard U.S. airlines, it should not impose such requirements on foreign airlines. Such requirements are unnecessary in the context of IMC implementation because IMC providers partner with licensed wireless carriers to deliver mobile broadband applications to the passenger. Furthermore, imposition of such service rules would be an unjustified intrusion into the foreign aircraft cabin. Like other services and activities onboard an aircraft, IMC is subject to the primary jurisdiction an airline's registering nation. The potential imposition of disparate IMC service requirements by overflown nations would conflict with well-accepted principles in international aviation and, again, would set a dangerous precedent for global in-flight connectivity offerings. Accordingly, the Commission should avoid "reaching into" the foreign aircraft cabin to impose service requirements on IMC operations onboard foreign aircraft.

2. IMC Requires Harmonized International Standards

IMC systems are currently installed on hundreds of aircraft and in-flight connectivity systems are installed on thousands more – many of which are engaged in international commercial aviation. IMC and related equipment, including components that provide the off-board link, travel virtually everywhere in the world pursuant to uniform standards developed by the communications and aviation industries. These standards are designed to ensure that equipment operations onboard aircraft are compatible with other systems and services, both on the ground and in the air.

The Commission should recognize the global nature of commercial aviation and the need to adopt harmonized standards to facilitate the provision of IMC by U.S. airlines on long-haul

international flights that cross multiple national boundaries. Adopting harmonized standards will also promote competition, enhance access to mobile broadband services and reduce costs by increasing scale in the global IMC marketplace for airlines, aircraft manufacturers, equipment integrators, service providers, wireless carriers and the U.S. traveling public.

3. The Commission Should Authorize IMC Even if Additional Standards Must Be Developed for U.S. Airlines

As a result of the Commission's initiative through the *NPRM*, interested parties (including U.S. airlines and wireless carriers) are now exploring the potential of IMC offerings and appropriate means for implementing IMC in the United States. However, these mobile broadband applications have been available on foreign airlines operating throughout the rest of the world for years. Although it may be appropriate to consider issues associated with the provision of IMC in the U.S. domestic market, the Commission should not delay adoption of international standards that may be employed by U.S. aircraft traveling internationally and foreign aircraft traveling in U.S. airspace.

AeroMobile would also note that many U.S. passengers on foreign airlines utilize mobile devices that include the frequencies and international roaming features necessary to access IMC today. The ability to access IMC will be even greater when next generation IMC equipment is introduced that has the additional service link band at 2100 MHz. Thus, the Commission can make IMC applications available to U.S. consumers even if it considers additional issues associated with more U.S.-specific IMC implementations.

E. Permitting IMC Operations Below 10,000 Feet Is Premature

The *NPRM* inquires about the possibility of AASs operations below the minimum altitude of 3,048 meters (10,000 feet) currently used to support global IMC offerings. The Commission asks specifically whether this service floor is appropriate for all mobile

technologies and bands, whether public safety entities could benefit from operations below this level, and whether allowing AASs to operate below the current minimum altitude could help prevent mobile devices from attempting to access terrestrial networks.²⁴

AeroMobile believes that the Commission should limit the operation of AASs to altitudes higher than 3,048 meters (approximately 10,000 feet) above ground. Existing studies suggest that this minimum separation distance is necessary to adequately protect terrestrial networks. Thus, although there may be some benefit in certain limited circumstances to permitting operation below the current minimum altitude, AeroMobile believes that additional studies would be required to support such operations.

F. The Commission Need Not Consider the Issue of Voice Services in this Proceeding

In the *NPRM*, the Commission does not propose to limit the types of IMC applications that can be provided onboard the aircraft. Instead, the ultimate decision relating to specific mobile broadband applications would be left to the airlines themselves.²⁵ To facilitate airline choice, IMC systems have settings that allow airlines to enable or disable individual mobile applications, including disabling voice connectivity.

AeroMobile believes that the Commission's objectives in this proceeding should be to further the public interest by facilitating the introduction of new mobile broadband services, extending the reach of existing networks, and protecting existing licensees from harmful interference. In contrast, the FAA and the U.S. Department of Transportation ("DoT") have the proper jurisdiction to address the potential impact of voice on passenger comfort, convenience

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 $^{^{24}}$ NPRM at ¶¶ 55, 70-71.

²⁵ *Id.* at 3-4, 25, 72-73.

and safety that have been raised with respect to the introduction of IMC in the United States. To the extent that such concerns persist, they should be addressed by those agencies. Nonetheless, AeroMobile believes that airlines remain in the best position to decide whether a particular IMC application is beneficial for their passengers.

AeroMobile agrees with comments submitted by Gogo Inc. in a recent proceeding indicating that the Commission's rules should not restrict the types of applications provided in the context of in-flight connectivity. Indeed, in adopting rules and policies for the 800 MHz air-ground service, the Commission expressly confirmed that it sought "to let marketplace forces, rather than prescriptive regulations, determine the highest valued air-ground service applications" and that "a new licensee may provide any type of air-ground services (*i.e.*, voice telephony, broadband Internet, data, etc.) to any aircraft type...."

There is no basis for the Commission to change its approach in the context of developing a regulatory regime for IMC in the United States.

Finally, AeroMobile would note that far from raising social or technical concerns, inflight voice, text and data connectivity is increasingly expected and relied upon. In fact, last year the FAA issued a study on the use of cell phones in flight, ²⁸ which confirmed that there were no reported cases of passenger disruption or flight attendant interference onboard a number of

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²⁶ See Comments of Gogo Inc., RM-11640 (filed Aug. 26, 2013) at 11-12.

²⁷ Id. at 12 (citing Amendment of Part 22 of the Commission's Rules to Benefit the Consumers of Air-Ground Telecommunications Services, Report and Order and Notice of Proposed Rulemaking, 20 FCC Rcd 4403, 4431 ¶52 (2005)).

²⁸ Study of the Use of Cell Phones Onboard Aircraft, Docket No. FAA-2012-0957, Notice of Availability and Request for Comments, 77 FR 54651 (rel. Sept. 5, 2012); Study of the Use of Cell Phones Onboard Passenger Aircraft, DOT/FAA/AR-12/30 (rel. July 2012) ("Cell Phone Study").

surveyed foreign airlines that offer voice connectivity. This study is consistent with AeroMobile's experience that demand for all mobile applications (voice, text and data) applications is growing rapidly, and that access to such communications applications greatly enhances the passenger experience.

G. Other Issues

1. Law Enforcement Concerns

The Commission proposes that IMC offered in the United States would be subject to the provisions of CALEA, and anticipates that IMC providers would work diligently with law enforcement agencies to address any public safety, law enforcement, and national security concerns through individual negotiations and agreements.²⁹ The Commission also asks whether the FCC should take measures beyond CALEA obligations and individual agreements to address in-flight safety and security concerns.³⁰

AeroMobile agrees that IMC is subject to CALEA and such additional capabilities as may be negotiated in the context of individual IMC system implementations. AeroMobile has worked with U.S. law enforcement agencies to address its current IMC offering and what additional measures may be appropriate to support IMC in the United States. AeroMobile therefore agrees with the Commission's conclusion that individual agreements are the best means to address law enforcement concerns regarding IMC and that the Commission should not impose any additional requirements.

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 $^{^{29}}$ *NPRM* at ¶¶ 3, 25, 75-77.

³⁰ *Id*.

2. Border Coordination with Canada and Mexico is Unnecessary

In the *NPRM* the Commission seeks comment on the necessity of modifying rules to codify future agreements with Canada and Mexico regarding IMC use of these bands.³¹ AeroMobile agrees with the Commissions that AAS operations must operate consistent with the terms of international agreements currently in force. However, due to the non-interfering nature of IMC services, border coordination agreements with Canada and Mexico are unnecessary. AAS operations are license exempt in Canada and Mexico, and the Commission is not in a position where it must codify any future agreements with Canada and Mexico regarding the use of IMC services on AAS-equipped aircraft.

VI. CONCLUSION

AeroMobile appreciates the efforts of the Commission to respond to the evergrowing consumer demand for consistent, flexible connectivity and to facilitate the introduction of IMC in the United States. AeroMobile believes that the most appropriate means for the Commission to achieve these objectives is to adopt a license-exempt/unlicensed approach for IMC equipment installed and operated onboard U.S. and foreign aircraft. The Commission might decide to supplement this approach with Part 87 aircraft station licensing for U.S.-registered aircraft to ensure that authority to operate IMC equipment is expressly established for aircraft that travel outside the United States. Finally, by adopting current IMC standards while developing additional U.S. domestic guidelines, facilitating existing commercial implementation of IMC offerings and accounting for the unique issues associated with IMC in international aviation, the Commission can achieve its objectives.

³¹ *NPRM* at \P 74

Respectfully submitted,

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February 14, 2014

ATTACHMENT: TECHNICAL APPENDIX



Technical Review of Frequency Bands for AAS Operations in U.S. Airspace

Introduction

This technical paper reviews the operation of the existing 2.5G and future 3G/LTE AeroMobile airborne access system ("AAS") on commercial aircraft overflying the United States.

Existing ECC reports 123 and CEPT Report 48^4 cover the mobile bands used in ITU Region 1 & 3 and the operation of GSM/UMTS and LTE connectivity. This paper reviews the potential impact of existing and future AAS designs on systems and services in the United States to assess whether the operation of these systems in U.S. airspace will cause interference.

The ECC Reports²³ divide the subject mobile bands into those used for on-board **connectivity** (initially 1800 MHz and then adding 2100 MHz) and those that need to be **controlled** to inhibit reception of a pilot signal from the ground networks. AASs utilise only the foregoing bands (E-UTRA Band 1 & 3) for connectivity to take advantage of low minimum power levels of the mobile devices accessing these bands, maximise the aircraft attenuation and RF path loss, resulting in very low EIRP levels outside the aircraft and on the ground.

Consistent with existing standards, AeroMobile proposes to continue using existing 1800MHz (E-UTRA Band 3) and 2100MHz (E-UTRA Band 1) connectivity bands for operation in U.S. airspace. This allows the existing equipment to be utilized for a global solution based on communications and aviation industry standards and processes to support in-flight GSM/UMTS and LTE connectivity.

The controlled bands are managed by a Network Control Unit (NCU) that raises the RF noise floor within the aircraft cabin, and thus the mobile device receiver, such that it cannot receive a pilot signal from the ground network. This, in turn, prevents the mobile device from transmitting at high power to connect directly with terrestrial base stations from the aircraft.

Today, with the large amount of mobile devices left "on" but not in "airplane mode" onboard aircraft, there are many aircraft flying over the USA with uncontrolled mobile devices currently trying to connect or connecting with the terrestrial network at high powers, with resultant interference to the terrestrial network from these high-power transmissions. In contrast, an aircraft equipped with an AAS employs the onboard NCU to shield the aircraft cabin and reduce the interference impact of otherwise uncontrolled devices on the ground network.

Connectivity and Controlled Bands

The current ECC Reports¹²³ cover the mobile bands given in <u>Table 1</u> that are used in the ITU Region1&3. The connectivity bands were selected at higher frequencies to maximise the attenuation and RF path loss and to utilise the lower levels of RF power control that the a-UE (airborne UE/MS) available in the higher bands. The highest band 2600MHz was rejected for connectivity due to the risk of interference to radio astronomy and adjacent weather radar services (See Section 8 ECC Report 187³).



<u>Table 2</u> shows the USA frequency bands defined in Footnote 8 of the NPRM, plus the addition of the 2.6 GHz band which we believe will be used for LTE TDD in the future, that may need to be controlled for future AAS operations.

	Constant to book	1710-1785 MHz (uplink)/ 1805-1880 MHz (downlink) (GSM /LTE1800)
	Connectivity bands:	1920-1980 MHz (Uplink)/ 2110-2170MHz (downlink) (UMTS2100)
		791-821 MHz (LTE 800)
	Controlled bands:	925-960 MHz (GSM/UMTS/LTE 900)
		1805-1880 MHz (GSM/UMTS/LTE1800)
		2110-2170 MHz (LTE/UMTS)
		2500-2690 MHz (LTE 2600)

Table 1 Existing AAS Frequency Bands

	698-759 MHz (LTE 700)
	869-894MHz (800)
USA Controlled	851-866, 935-940 MHz (SMR)
bands:	1930-1995 MHz (PCS)
	2110-2155 (AWS)
	2180-2200 (AWS-4)
	2345-2360 (WCS)

Table 2 US-Specific Controlled Bands

<u>Figure 1</u>, below, itemizes the bands studied by the EU versus those identified in NPRM Footnote 8, plus the 2600 MHz band that we believe will be used in the United States for LTE TDD. Also the AeroMobile system is capable of covering the 3.5 and 3.8 GHz bands when introduced.



Figure 1 Cellular Band Overlap with existing ECC Reports

Overlaps in the spectrum defined in the ECC Reports vis-à-vis U.S. bands (thus requiring additional compatibility assessments) include:



NCU => US SMR Downlink (UE Rx) NCU => US PCL Uplink (Node B Rx)
1800MHz UL ac_UE => US AWS UL (Node B Rx)
2100MHz DL ac_Node B => US AWS DL (UE Rx)
US AWS DL Node B Tx => 2100MHz DL (ac_UE)

These scenarios are evaluated in separate sections of this technical paper.

Connectivity Bands

The AAS currently operates in E-UTRA Band 3 (1800 MHz) for GSM and proposes to continue operation in that band for 3G and LTE. In addition a second connectivity band was defined in CEPT and the ECC^{34} reports in March 2013 for the use of the E-UTRA Band 1 (2100 MHz) for UMTS.

<u>Figure 2</u> shows the overlapping aspects of utilising the existing connectivity bands system with the USA Federal and Cellular networks. Each overlapping scenario (A to D) is addressed later in the document.

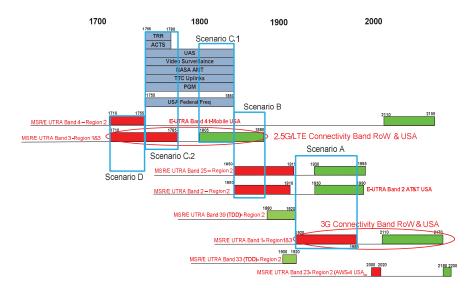


Figure 2 Connectivity Band Overlap with US Mobile and Federal Bands



Analysis

The following analysis utilizes reference data from various ECC Reports. 123

This analysis first reproduces Scenario 1, 2 and 3 as defined in Page 9 of ECC Report 187³ and adds the additional USA bands defined in <u>Table 2</u>. These scenarios are described below. Minimum Coupling Loss was concluded as being the worst case in the ECC technical meetings so this analysis does not cover any SEAMCAT analysis.

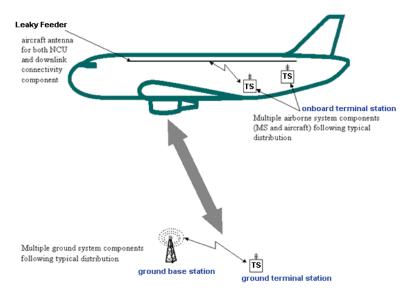


Figure 3 ACC and Ground Based cellular interference scenario

This paper will repeat the three scenarios described below to include the USA bands defined in $\underline{\underline{\text{Table 2}}}$. It will also separately examine the overlap of the proposed connectivity bands as shown in Figure 2 for Scenario A through D.

Scenario 1: Impact of ground base station (g-NodeB¹) to the ac-UE. This scenario, using a minimum coupling loss (MCL) approach, identifies the conditions in which the mobile terminal on aircraft (ac-UE²) will have visibility of the ground-based networks. Note that the NCU and aircraft base station (ac-NodeB) are not taken into account in this scenario. The ac-UE/ac-MS³ are operating uncontrolled and assumed to be at full power (e.g. not connected to the on-board system).



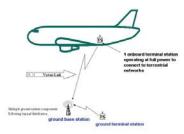
 $^{^{\}rm 1}$ g-NodeB is the standard terminology used for Ground Node B

² ac-UE is the standard terminology used for aircraft user equipment (UMTS and LTE)

³ ac-MS is the standard terminology used for aircraft mobile station (GSM)



Scenario 2: Impact of the ac-UE to g-NodeB. This scenario, using both MCL approach assessed in which conditions the ac-UE will have the ability to connect to ground-based networks, and in that case, the impact on other ground-based links. Note that the NCU and ac-NodeB are not taken into account in this scenario. The ac-UE/ac-MS are operating uncontrolled and assumed to be at full power (e.g. not connected to the on-board system).

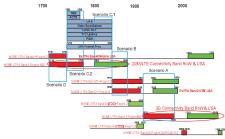


 Scenarios 3: Impact of onboard NCU⁴ and ac-NodeB emissions to the downlink of ground-based networks, for single aircraft.



 US Specific Scenarios A-D: As discussed above, there is an overlap in using the existing E-UTRA Band 3 (1800 MHz) band in the United States. Because an on-board 1800 MHz ac-UE/ac-MS will

not transmit unless it sees a broadcast pilot channel there is no possibility of devices transmitting at full power in this band. For that reason, there is also no need for the NCU to operate in the 1800 MHz band in the United States. The onboard ac-MS and ac-UE will be controlled to their minimum EIRP RF power of OdBm, -6dBm, +8dBm for GSM, UMTS and LTE, respectively.



Current plans are only to operate GSM and LTE in the 1800MHz band but UMTS has been added for completeness.

 $^{^4}$ NCU - Network Control Unit is the element of the AAS that lifts the RF noise floor in the downlink of the mobile bands that the aircraft is overflying.



As noted above, there are four scenarios that need to be examined for the United States given the differences in frequency allocations:

- A. ac-UE TX (operating in the 1920-1980MHz) -> g-UE RX (operating in the 1930-1980MHz),
- ac-NodeB/BTSBTS TX (operating in the 1805-1880MHz) -> g-NobeB RX (operating in the 1850-1915MHz),
- C. US Federal Overlap

ac-NodeB/BTS TX (operating in the 1805-1880MHz) -> US Fed RX(1805-1850MHz) ac-UE/MS TX (operating in the 1755-1785MHz) -> US Fed RX (1755-1785MHz)

D. ac-UE/MS TX (operating in the 1710-1755MHz) -> g-Node RX (operating 1710-1775MHz)

Scenario 1 g-NodeB to ac UE

<u>Table 3</u> to <u>Table 19</u>, below, use the following calculations and input to derive the received signal levels within the aircraft cabin for the current AAS and new U.S. bands under consideration:

Path Loss = $92.4 + 20 \log(d) + 20 \log(f)$ where d is in kilometers and f is in GHz

A g-NodeB LTE EIRP power from ECC Report 187^2 Table 15 is given as +64dBm when using a 15dBi antenna. The figures in the LTE Tables are corrected to give the EIRP (dBm) at the worst case elevation angle of 48° for 700/800 MHz using the following equation:

 $\textit{LTE EIRP at } 48^{\circ} \, (\textit{dBm}) = \textit{Transmit EIRP Power } \, (\textit{dBm}) - \textit{Antenna Gain } \, (\textit{dBi}) \, \, \textit{at } 0^{\circ} + \textit{Antenna Gain at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, (\textit{dBi}) \, \, \textit{at } 0^{\circ} + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm}) + \textit{Antenna Gain } \, \textit{at } 48^{\circ} \, (\textit{dBm})$

$$EIRP \text{ at } 48^{\circ} = 64 - 15 - 0.34 = 48.66dBm (at 700/800MHz)$$

The same equipment and antenna transmit and antenna gains are used for the 700 MHz LTE g-Node B and antenna respectively as we do not believe that the performance of the equipment will be significantly better at 700 MHz.

For the g_Node B LTE for the 900, 1800, 2100, 2600 use a +43dBm Antenna Input Power giving the EIRP at 48° as:

EIRP at 48° = Antenna Transmit Power + Antenna Gain at 48°

The same parameters were used for 1900 and 2300 MHz frequencies.

The Max Rx Power in aircraft takes into account a 5dB aircraft attenuation agreed in ECC Report 93 Table 13.

The *Margin* is the level above sensitivity using -97dBm/10MHz for LTE and -114dBm and -117dBm for 800 to 1900MHz and 2100 to 2600MHz. A negative margin indicates that the ac-UE can receive a signal on-board the aircraft that can results in transmission to the ground by the ac-UE.

<u>Table 3</u> (700MHz) and <u>Table 6</u> (800MHz) differs by approximately 1.1dB due to the reduced propagation path loss so there is a higher received signal in the cabin at 700MHz. For UMTS/LTE



Table 11 & Table 12 (1800MHz) and Table 14 & Table 15 (1900MHz) there is approximately 0.4dB increase in propagation path loss reducing the signal in the cabin.

For each table in Scenario 1, a negative margin indicates that the onboard ac-MS/ac-UE would receive the signal from a g-BTS/g-Node B, and thus would start transmitting at high power to connect to the terrestrial network. In other words, a negative margin is not desired. As indicated in Tables 3 through 19 below (covering various bands and technologies) below, all frequency bands result in a negative (undesired) margin in an uncontrolled environment, establishing that an NCU is necessary to control the RF environment within the aircraft cabin to facilitate successful AAS operations.

LTE 700MHz (USA)

	LTE		9		700MH	ž.	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_BTS Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	101.4	-0.34	48.66	-57.77	-39.23
4000	48	5.38	103.9	-0.34	48.66	-60.26	-36.74
5000	48	6.73	105.9	-0.34	48.66	-62.20	-34.80
6000	48	8.07	107.4	-0.34	48.66	-63.78	-33.22
7000	48	9.42	108.8	-0.34	48.66	-65.12	-31.88
8000	48	10.76	109.9	-0.34	48.66	-66.28	-30.72
9000	48	12.1	111.0	-0.34	48.66	-67.30	-29.70
10000	48	13.45	111.9	-0.34	48.66	-68.22	-28.78

Table 3 LTE g-NodeB to ac-UE at 700MHz

800MHz ITU Region 1&3 - USA 800 MHz

	GSM			
Aircraft height ahove ground	Worst case elevation angle (°)	Distance aircraft / base station	Max Rx. Power in aircraft (dBm /	Margin (dB)
3000	48	4.04	-72.50	-24.50
4000	48	5.38	-74.90	-22.10
5000	48	6.73	-76.70	-20.30
6000	48	8.07	-78.20	-18.80
7000	48	9.42	-79.50	-17.50
8000	48	10.76	-80.60	-16.40
9000	48	12.1	-81.50	-15.50
10000	48	13.45	-83.30	-13.70

Table 4 g-BTS (GSM) to ac-MS at 800 MHz



	800MHz						
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margir (dB)
3000	48	4.04	102.6	-10.4	38.6	-68.99	-45.01
4000	48	5.38	105.1	-10.4	38.6	-71.48	-42.52
5000	48	6.73	107.0	-10.4	38.6	-73.42	-40.58
6000	48	8.07	108.6	-10.4	38.6	-75.00	-39.00
7000	48	9.42	109.9	-10.4	38,6	-76.34	-37.66
8000	48	10.76	111.1	-10.4	38.6	-77.50	-36.50
9000	48	12.1	112.1	-10.4	38.6	-78.52	-35,48
10000	48	13.45	113.0	-10.4	38.6	-79.44	-34.56

Table 5 UMTS g-NodeB to ac-UE at 800MHz

	LTE				800MH	2	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48*	g_Node B EIBF (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	102.6	+0.34	48.66	-58.93	-38.07
4000	48	5.38	105.1	-0.34	48.66	-61.42	-35.58
5000	48	6.73	107.0	-0.34	48,66	-63.36	-33.64
6000	48	8.07	108.6	-0.34	48.66	-64.94	-32.06
7000	48	9.42	109,9	-0.34	43.66	-66.28	-30.72
8000	48	10.76	111.1	-0.34	48,66	-67,44	-29.56
9000	48	12,1	112.1	-0.34	48.66	-68,46	-28.54
10000	48	13.45	113.0	-0.34	43.66	-69.38	-27.62

Table 6 LTE g-NodeB to ac-UE at 800MHz



900MHz (ITU Region 1&3) + SMR USA

	GSM			
height above ground (m)	Worst case elevation angle (°)	aircraft / base station (km)	Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	-73.50	-23.50
4000	48	5.38	-75.90	-21.10
5000	48	6.73	-77.70	-19.30
6000	48	8.07	-79.20	-17,80
7000	48	9.42	-80.50	-16.50
8000	48	10.76	-81.60	-15.40
9000	48	12.1	-82.50	-14.50
10000	48	13.45	-83.30	-13.70

Table 7 g-BTS (GSM) to ac-MS at 900MHz (from ECC Report 93 Table 24)

	UMTS				900MHz	r.	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	103.6	-10.4	22.6	-86.01	-27.99
4000	48	5.38	106.1	-10.4	22.6	-88.50	-25.50
5000	48	6.73	108.0	-10.4	22.6	-90.45	-23.55
6000	48	8.07	109.6	-10.4	22.6	-92.02	-21.98
7000	48	9.42	111.0	-10.4	22.6	-93.37	-20.63
8000	48	10.76	112.1	-10.4	22.6	-94.52	-19.48
9000	48	12.1	113.1	-10.4	22.6	-95.54	-18.46
10000	48	13.45	114.1	-10.4	22.6	-96.46	-17.54

Table 8 UMTS g-NodeB to ac-UE at 900MHz

	LTE		900MHz					
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss	g_NodeB Antenna Bain (dBi) @48*	€ Node 8 EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (d8)	
3000	48	4.04	103.6	-1.84	41.16	-67.45	-29.55	
4000	48	5.38	106.1	-1.84	41.16	-69.94	-27.06	
5000	48	6.73	108.0	-1.84	41.16	-71.89	-25.11	
6000	48	8.07	109.6	-1.84	41.16	-73.46	-23.54	
7000	48	9.42	111.0	-1.84	41.16	-74.81	-22.13	
8000	48	10.76	112.1	-1.84	41.16	-75.96	-21.04	
9000	48	12.1	113.1	-1.84	41.16	-76.98	-20.02	
10000	48	13.45	114.1	-1.84	41.16	-77.90	-19.10	

Table 9 LTE g-NodeB to ac-UE at 900MHz



1800MHz (ITU Region 1 & 3)

	G5M	1800MHz		
Aircraft height above ground	Worst case elevation angle (°)	Distance aircraft / base station	Max Rx. Power in aircraft (dBm /	Margin (dB)
3000	48	4.04	-81.70	-15.30
4000	48	5.38	-82.60	-14.40
5000	48	5.73	-83.50	-13.50
6000	48	8.07	-84.30	-12.70
7000	48	9.42	-85.00	-12.00
8000	48	10.76	-85.60	-11.40
9000	48	12.1	-86.10	-10.90
10000	48	13.45	-86.50	-10.50

Table 10 g-BTS (GSM) to ac-MS at 1800MHz (from ECC Report 93 Table 24)

UMTS			1800MHz					
Aircraft height above ground (m)	World case elevation angle (*)	Distance aircraft / base station (km)	l'áth loss (dB)	g_NodeB Antenna Gain (dBi) @48*	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)	
3000	48	4.04	109.6	-10.4	22.6	-92.03	-21.97	
4D00	48	5.38	117.1	-10.4	22.6	+94.52	-19.48	
5000	48	6.73	114.1	-10.4	22.6	-96.47	-17.53	
6000	48	8.07	115.6	-10.4	22.6	-98.04	-15.96	
7000	48	9.42	117.0	-10.4	22.6	-99,39	-14.61	
8000	48	10.76	118.1	-10.4	22.6	-100.54	-13.46	
9000	48	12.1	119.2	-10.4	22.6	-101.56	-12.44	
10000	48	13.45	120.1	-10.4	22.6	-102.48	-11.52	

Table 11 UMTS g-NodeB to ac-UE at 1800MHz

	1800MHz						
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margir (dB)
3000	48	4,04	109.6	-1.84	41.16	+73.47	-23.53
4000	48	5.38	112.1	-1.84	41.16	-75.96	-21.04
5000	48	6.73	114.1	-1.84	41.16	-77.91	-19.09
6000	48	8.07	115.6	-1.84	41.16	-79.48	-17.52
7000	48	9.42	117.0	-1.84	41.16	-80.83	-16.17
8000	48	10.76	118.1	-1.84	41.16	-81.98	-15.02
9000	48	12.1	119.2	-1.84	41.16	-83.00	-14.00
10000	48	13.45	120.1	-1.84	41.16	-83.92	-13.08

Table 12 LTE g-NodeB to ac-UE at 1800MHz



1900MHz (PCS + Region 2)

	G5M		1900	MHz	
Aircraft height above ground	Worst case elevation angle (°)	Distance aircraft / base station	Max Rx. Power in aircraft (dBm /	Margin (dB)	
3000	48	4.04	-82.20	-14.80	
4000	48	5.38	-83.10	-13.90	
5000	48	6,73	-84,00	-13.00	
6000	48	8.07	-84,80	-12.20	
7000	48	9.42	-85.50	-11.50	
8000	48	10.76	-86.10	-10.90	
9000	48	12.1	-86.60	-10.40	
10000	48	13.45	-87.00	-10.00	

Table 13 g-BTS (GSM) to ac-MS at 1900MHz

	UMTS				1900MH	Z	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	110.1	-10.4	22.6	-92.50	-21.50
4000	48	5.38	112.6	-10.4	22.6	-94.99	-19.01
5000	48	6.73	114.5	-10.4	22.6	-96.94	-17.06
6000	48	8.07	116.1	-10.4	22.6	-98.51	-15.49
7000	48	9.42	117.5	-10.4	22.6	-99.86	-14.14
8000	48	10.76	118.6	-10.4	22.6	-101.01	-12.99
9000	48	12.1	119.6	-10.4	22.6	-102.03	-11.97
10000	48	13.45	120.5	-10.4	22.6	-102.95	-11.05

Table 14 UMTS g-NodeB to ac-UE at 1900MHz

	LTE				1900MH	z	
Aircraft height	Worst case	Distance aircraft /	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48*	≥ Node B EIRP (dBm)	Max Rx. Power in	Matgin (dB)
3000	48	4.04	110.1	-1.84	41.16	-73.94	-23.06
4000	48	5.38	112.6	-1.84	41.16	-76.43	-20.57
5000	48	6.73	114.5	-1.84	41.16	-78.38	-18.62
6000	48	8.07	116,1	-1.84	41.16	-79.95	-17.05
7000	48	9,42	117.5	-1.84	41.16	-81.30	-15.70
8000	48	10.76	118.6	-1.84	41.16	-82.45	-14.55
9000	48	12.1	119.6	-1.84	41.16	-83.47	-13.53
10000	48	13.45	120.5	-1.84	47.16	-78.39	-18.61

Table 15 LTE g-NodeB to ac-UE at 1900MHz



2100MHz (Region 1&3) - AWS/AWS-4

	UMTS				2100MH	Z	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	111.0	-10.4	22.6	-93.37	-23.63
4000	48	5.38	113.5	-10.4	22.6	-95.86	-21.14
5000	48	6.73	115.4	-10.4	22.6	-97.80	-19.20
6000	48	8.07	117.0	-10.4	22.6	-99.38	-17.62
7000	48	9.42	118.3	-10.4	22.6	-100.73	-16.27
8000	48	10.76	119.5	-10.4	22.6	-101.88	-15.12
9000	48	12.1	120.5	-10.4	22.6	-102.90	-14.10
10000	48	13.45	121.4	-10.4	22.6	-103.82	-13.18

Table 16 UMTS g-NodeB to ac-UE at 2100MHz

-	LTE		3		2100MH	z	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margin (dB)
3000	48	4.04	111.0	-1.84	41.16	-74.81	-22.19
4000	48	5.38	113.5	-1.84	41.16	-77.30	-19.70
5000	48	6.73	115.4	-1.84	41.16	-79.24	-17.76
6000	48	8.07	117.0	-1.84	41.16	-80.82	-16.18
7000	48	9.42	118.3	-1.84	41.16	-82.17	-14.83
8000	48	10.76	119.5	-1.84	41.16	-83.32	-13.68
9000	48	12.1	120.5	-1.84	41.16	-84.34	-12.66
10000	48	13.45	121.4	-1.84	47.16	-79.26	-17.74

Table 17 LTE g-NodeB to ac-UE at 2100MHz

2300MHz (WCS)

	LTE				2300MH	Z	
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss (dR)	g_NodeB Antenna Gain (dBi) @48*	//_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / th)	Margin (dB)
3000	48	4.04	111.8	-1.84	41.16	-75.60	-21.40
4000	48	5.38	114.3	-1.84	41.16	-78.09	-18.91
5000	48	6.73	116.2	-1.84	41.16	-80.03	-16.97
6000	48	8.07	117.8	-1.84	41.16	-81.61	-15.39
7000	48	9.42	119.1	-1.84	41.16	-82.96	-14.04
8000	48	10.76	120.3	-1.84	41.16	-84.11	-12.89
9000	48	12.1	121.3	-1.84	41.16	-85.13	-11.87
10000	48	13.45	122.2	-1.84	47.16	-80.05	-16.95

Table 18 LTE g-NodeB to ac-UE at 2300MHz



2600MHz (USA TDD LTE + Region 1&3)

	LTE				2600		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48°	g_Node B EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Margir (dB)
3000	48	4.04	112.8	-1.84	41.16	-76.67	-20.33
4000	48	5.38	115.3	-1.84	41.15	-79.16	-17.84
5000	48	6.73	117.3	-1.84	41.16	-81.10	-15.90
6000	48	8.07	118.8	-1.84	41.16	-82.68	-14.32
7000	48	9.42	120.2	-1.84	41.16	-84.02	-12,98
8000	48	10.76	121.3	-1.84	41.16	-85.18	-11.82
9000	48	12.1	122.4	-1,84	41.16	-86,20	-10.80
10000	48	13.45	123.3	-1.84	47.16	-81.11	-15.89

Table 19 LTE g-NodeB to ac-UE at 2600MHz

For all cellular bands analysed there is a negative margin which indicates that the ac-MS/UE is capable of receiving a pilot signal from the terrestrial network.

Scenario 2 ac UE to g NodeB

<u>Table 20</u> to <u>Table 36</u> shows ac-UE/MS at <u>full power</u> (i.e., not connected to the onboard system and commanded to its lowest power state). For GSM ac-MS this is +33 dBm/ch for 800/900MHz, +30dBm/ch for 1800/1800MHz, for ac-UE for UMTS +21 dBm/ch and +23 dBm/10 MHz for LTE. For controlled devices used in the E-UTRA Band 1 & 3 these levels reduce to 0dBm, -6dBm and +8dBm/10MHz for GSM/UMTS and LTE, respectively.

A negative margin indicates that the ac-MS/UE can successfully connect to the terrestrial network when transmitting at its maximum EIRP. In contrast, a positive margin would show an inability to connect to the terrestrial network. Although there are some positive margins at higher frequencies, the tables below demonstrate that ac-MS/UEs must be commanded to their lowest power state to avoid connections with or interference to the ground network. Regardless of whether an ac-MS/UE connects the the terrestrial network, its high power transmissions would raise the noise floor far greater than a controlled ac-MS/UE transmitting at its lowest power state.

700MHz USA LTE



			LT	E				
	LTE		-		3	700MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Path loss (dB)	g_NodeB Antenna Gain (dBi) @48*	ac_UE EIRP (dBm)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dB)
3000	48	4.04	101.4	-0.34	23	-83.77	-101.50	-17.73
4000	48	5.38	103.9	-0.34	23	-86.26	-101.50	-15.24
5000	48	6.73	105.9	-0.34	23	-88.20	-101.50	-13.30
6000	48	8.07	107.4	-0.34	23	-89.78	-101.50	-11.72
7000	48	9.42	108.8	-0.34	23	-91.12	-101.50	-10.38
8000	48	10.76	109.9	-0.34	23	-92.28	-101.50	-9.22
9000	48	12.1	111.0	-0.34	23	-93.30	-101.50	-8.20
10000	48	13,45	111.9	-0.34	23	-94.22	-101.50	-7.28

Table 20 LTE ac-UE to g-NodeB at 700MHz

800MHz ITU Region 1&3 - USA 800MHz

	GSM				
Aircraft height above ground (m)	Worst case elevation angle (9)	Distance aircraft / base station (km)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin
3000	2	4.04	-84.52	-104.00	-19.48
4000	48	5.38	-84.52	-104.00	-19.48
5000	48	6.73	-84.52	-104.00	-19.48
6000	48	8.07	-84.52	-104.00	-19.48
7000	48	9.42	-84.52	-104.00	-19.48
8000	48	10,76	-84.52	-104.00	-19.48
9000	48	12.1	-84.52	-104.00	-19,48
10000	48	13.45	-84.52	-104.00	-19.48

Table 21 GSM ac-MS to g-BTS at 800MHz (derived from Table 25 ECC Report 93)

	UMTS					800MHz		
Aircraft freight above ground (m)	Worst case elevation angle (°)	Dietance aircraft / base station (km)	Path loss (dB)	g_NodeB Amenna Gain (dBi) ga48*	ac_UF EIRP	Max Rx. Power g Node B(dBm / zh)	Reference receiver sensitivity (dBm/ch)	Margin (d8)
3000	48	4.04	102.6	-10.4	21	-96.99	-121.00	-24.01
4000	48	5.38	105.1	-10.4	21	-99.48	-121.00	-21.52
5000	48	6.73	107.0	-10,4	21	101.42	-121.00	19.58
6000	48	8.07	108.6	-10.4	21	-103.00	-121.00	-18.00
7000	48	9.42	109.9	-10.4	21	-104.34	-121.00	-16.66
8000	48	10.76	111.1	-10.4	51	-105.50	-121.00	-15.50
9000	48	12.1	112.1	-10.4	21	-106.52	-121.00	-14,48
10000	48	13.45	113.0	-10,4	21	-107.44	-121.00	-13.56

Table 22 UMTS ac-UE to g-NodeB 800MHz



	LTE					800MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dBi) @48*	ac_UE EIRP	Max Rx. Power g: Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)
3000	48	4.04	102.6	-0.34	23	84.93	-101.50	-16.57
4000	48	5.38	105.1	-0.34	23	-87.42	-101.50	-14.08
5000	48	6.73	107 E	-0.34	23	-89.36	-101.50	-12.14
6000	48	8.07	108.6	-0.34	23	-90.94	-101.50	-10.56
7000	48	9.42	109.9	-0.34	23	92.28	101.50	9.22
8000	48	10.76	111.1	-0.34	23	93.44	-101.50	-8.06
9000	48	12.1	112.1	-0.34	23	-94.46	-101.50	-7.04
10000	48	13.45	113.0	-0.34	23	-95.38	-101.50	-6.12

Table 23 LTE ac-UE to g-NodeB at 800MHz

900MHz (ITU Region 1&3) + SMR USA

	GSM				
Aircraft height above ground (m)	Worst case elevation angle	Distance aircraft / base station (km)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dB)
3000	48	4.04	-94.70	-104.00	-9.30
4000	48	5.38	-96.90	-104.00	-7.10
5000	48	6.73	-98.50	-104.00	-5.50
6000	48	8.07	-09.80	-104.00	4.20
7000	48	9.42	-100.90	-104.00	-3.10
8000	48	10.76	-101.80	-104.00	-2.20
9000	48	12.1	-102.60	-104.00	-1.40
10000	48	13.45	-103.30	-104.00	-0.70

Table 24 GSM ac-MS to g-BTS (from Table 25 ECC Report 93) at 900MHz

	UMTS					900MHz		
Aircraft freight above ground (m)	Worst case elevation angle (⁰)	Distance aircraft / base station (km)	Path loss	g_NodeB Antenna Gain (dBi) @48*	ac_UF FIRP (dBm)	Max Rx. Power g Node B(dBm / zh)	Reference receiver sensitivity (dBm/ch)	Margin (d8)
3000	48	4.04	103.6	<10.4	21	-98.01	-121.00	-22.99
4000	48	5.38	106.1	-10.4	21	-100.50	-121.00	-20.50
5000	48	0.73	108.0	-10.4	21	-102.45	-121.00	-18.55
6000	48	9.07	109.6	-10.4	21	-104.02	-121.00	-16.98
7000	48	9,42	111.0	-10.4	21	-105.37	-121.00	-15.63
8000	48	10.76	112.1	-10.4	21	-106.52	-121.00	-14.48
9000	48	12.1	113.1	-10.4	21	-107.54	-121.00	-13.46
10000	48	13.45	114.1	-10.4	21	-108.46	-121.00	-12.54

Table 25 UMTS ac-UE to g-NodeB 900MHz



	LTE					900MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dBi) @48*	ac_LIE EIRP (dBm)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dD)
3000	48	4.04	103.6	-1.84	23	-87.45	-101.50	-14.05
4000	48	5.38	106.1	-1.84	23	-89.94	-101.50	-11.56
5000	48	6.73	108.0	-1.84	25	-91.89	-101.50	-9.61
6000	48	8.07	109.6	-1.84	23	-93.46	-101.50	-8.04
7000	48	9.42	111.0	-1.84	23	94,81	+101.50	-6.69
8000	48	10.76	112.1	-1.84	23	95.96	-101.50	5.54
9000	48	12.1.	113.1	-1.84	23	-96,98	-101.50	-4.52
10000	48	13.45	114.1	-1.84	23	-97.90	-101.50	-3,60

Table 26 LTE ac-UE to g-BTS at 900MHz

1800MHz (ITU Region 1 & 3)

	GSM				
Aircraft height above ground [m]	Worst case elevation angle	Distance aircraft / base station (km)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)
3000	2	4.04	-94.70	-104.00	-9.30
4000	48	5.38	-96.90	-104.00	-7.10
5000	48	6.73	-98.50	-104.00	-5.50
6000	48	8.07	+99.80	-104.00	-4.20
7000	48	9.42	-100.90	-104.00	-3.10
8000	48	10.76	-101.80	-104.00	-2.70
9000	48	12.1	-102.60	-104.00	+1.40
10000	48	13.45	-103.30	-104.00	-0.70

Table 27 GSM ac-MS to g-BTS (from Table 25 ECC Report 93) at 1800MHz

	UMTS					1800MHz		
Aircraft height	Worst case slevation angle (0)	Distance aircraft /	Path loss	g_NodeB Antenna Gain (dBi) @48°	ac_UE EIRP (dBm)	Max Rx. Power g Node B(dBm // ch)	Reference receiver sensitivity (dBm/ch)	Margin
3000	48	4.64	109.6	-10.4	-21	104.63	-121.00	-16-97
4000	48	5.38	112.1	10.4	21	-106.52	-121.00	-14:48
5000	48	6.73	114.1	-10.4	51	-108,47	-121.00	-12.53
6000	48	8.07	115.6	-10.4	21	-110.04	-121.00	-10.95
7000	48	9.42	117.0	-10.4	21	-111.39	-121.00	-9.61
2000	48	10,76	118.1	-10.4	21	-112.54	-121.00	-8.46
9000	48	12.1	119.7	-10.4	21	-113.56	-121.00	-7,44
10000	48	13.45	120.1	-10.4	21	-114.48	-121.00	-6.52

Table 28 UMTS ac-UE to g-NodeB 1800MHz



	LTE					L800MHz		Т
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss	e_NodeB Antenna Gain (dBi)	ac_UE EIRP	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dll)
3000	48	8.84	109.6	-1.34	73	-92.97	101.50	8.53
4000	48	5.38	112.1	-1.34	23	-95.46	-101.50	-6.04
5000	48	6.73	114.1	-1.34	23	97.41	-101.50	-4.09
6000	48	8.07	115.6	-3.34	23	-98.98	-101.50	-2.52
7000	48	9.42	117.0	-1.34	23	-100.33	-101.50	-1.17
8000	48	10.76	118.1	-2.34	23	-101.48	-101.50	-0.02
9000	48	12.1	119.2	-1.34	23	-102.50	-101.50	1.00
10000	48	13.45	120.1	-1.34	23	-103.42	-101.50	1.92

Table 29 LTE ac-UE to g-NodeB at 1800MHz

1900MHz (PCS + ITU Region 2)

	GSM				
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Max Rx. Power g-Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dB)
3000	48	4.04	95.17	184.00	8.83
4000	48	5.38	-97.37	-104.00	-6.63
5000	48	6.73	-98.97	-104.00	-5.03
6000	48	3.07	-100.27	-104.00	-3.73
7000	48	9.42	+101.37	-104.00	-2.63
8000	48	10.76	-102,27	-104.00	-1.73
9000	48	12.1	-103.07	-104.00	-0.93
10000	48	13.45	-103.77	+104.00	-0.23

Table 30 GSM ac-MS to g-BTS (derived from Table 25 ECC Report 93) at 1900MHz

	UMTS					1900MHz		
Aircraft fieight: above ground (m)	Worst case elevation angle (⁰)	Dietance aircraft / base station (km)	Path loss	g_NodeB Amenna Gain (dBi) @48*	ac_UE FIRP (dBm)	Max Rx. Power g Node B(dBm / zh)	Reference receiver sensitivity (dBm/ch)	Margin (dB)
3000	48	4.04	110.1	-10.4	21	-104.50	-121.00	-16.50
4000	48	5.38	112.6	-10.4	21	-106.99	-121.00	-14.01
5000	48	0.73	114.5	-10.4	21	108.94	-12L00	-12.06
6000	48	9.07	116.1	-10.4	21	-110.51	-121.00	-10.49
7000	48	9.42	117.5	10.4	21	-111.86	-121.00	-9.14
8000	48	10.76	118.6	-10.4	21	-113.01	-121.00	-7.99
9000	48	12.1	119.6	-10.4	21	-114.03	-121.00	-6.97
10000	48	13,45	120.5	-10.4	21	-114.95	-121.00	-6.05

Table 31 UMTS ac-UE to g-NodeB 1900MHz



	LTE					L900MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dBi) @48*	ac_UE EIRP	Max Rx. Power 6 Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dD)
3000	48	4.04	110.1	-1.34	23	-93.44	-101.50	-8.05
4000	48	5.38	112.6	-1.34	23	-95.93	-101.50	-5.57
5000	48	6.73	114.5	-1.34	23	-97.88	-101.50	-3.62
6000	48	8.07	116.1	-1.34	23	-99.45	-101.50	-2.05
7000	48	9.42	117.5	-1.34	23	-100.80	+101.50	-0.70
8000	48	10.76	118.6	-1.34	23	-101.95	-101.50	0.45
9000	48	12.1	119.6	-1.34	23	-102.97	-101.50	1.47
10000	48	13.45	120.5	-1.34	23	-103.89	-101.50	2.39

Table 32 LTE ac-UE to g-NodeB at 1900MHz

2100MHz (ITU Region 1&3) - AWS/AWS-4

	UMTS					2100MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Dietance aircraft / base station (km)	Path loss	g_NodeB Antenna Gain (dBi) ga48*	ac_UE EIRP	Max Rx. Power g Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)
3000	48	4.04	111.0	-10.4	21	-105.37	-121.00	-15.63
4000	48	5.38	113.5	-10.4	21	-107.86	-121.00	-13.14
5000	48	6.73	115.4	-10.4	21	-109.80	-121.00	-11.20
6000	48	8.07	117.0	-10.4	21	-111.38	-121.00	-9.62
7000	48	9.42	118.3	-10.4	21	112.73	-121.00	-8.27
8000	48	10.76	119.5	-10.4	21	-113.88	-121.00	-7.12
9000	48	12.1	120.5	-10.4	21	-114.90	-121.00	-6.1D
10000	48	13,45	121.4	-10.4	21	-115.82	-12L.00	-5.18

Table 33 ac-UE to g-NodeB 2100MHz

	LTE					2100MHz		
Aircraft height above ground (m)	Worst case elevation angle (0)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dfii) @48*	ac_UE EIRP	Max Rx. Power 6 Node 8(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin
3000	48	4.04	111.0	-1.84	23	-94.81	-101.50	-6.69
4000	48	5.38	113.5	-1.84	23	-97.30	-101.50	-4.20
5000	48	6.73	115.4	-1.84	25	-99.24	-101.50	-2.26
6000	48	8.07	117.0	-1.84	23	-100.82	-101.50	-0.68
7000	48	9.42	118.3	-1.84	23	-102.17	-101.50	0.67
8000	48	10.76	119.5	-1.84	23	103.32	-101.50	1.82
9000	48	12.1	120.5	-1.84	23	-104.34	-101.50	2.84
10000	48	13.45	121.4	-1.84	23	-105.26	-101.50	3.76

Table 34 LTE ac-UE to g-NodeB at 2100MHz

2300MHz (WCS)

Reviewing FCC website looks like WCS is used for LTE (at least AT&T)



	LTE					2300MHz		
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dBi) @48*	ac_UE EIRP	Max Rx. Power 6 Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)
3000	48	4.04	111.8	-1.84	23	-95.60	-101.50	-5.90
4000	48	5.38	114.3	-1.84	23	-98.09	-101.50	-3.41
5000	48	6.73	116.2	-1.84	25	-100.03	-101.50	-1.47
6000	48	8.07	117.8	-1.84	23	-101.61	-101.50	0.11
7000	48	9.42	119.1	-1.84	23	-102.96	101.50	1.46
8000	48	10.76	120.3	-1.84	23	-104.11	-101.50	2.61
9000	48	12.1	121.3	-1.84	23	-105.13	-101.50	3.63
10000	48	13.45	122.2	-1.84	23	-106.05	-101.50	4.55

Table 35 LTE ac-UE to g-NodeB at 2300MHz

2600MHz (USA TDD LTE + ITU Region 1&3)

	LTE					2600MHz		
Aircraft height above ground (m)	Worst case elevation angle (0)	Distance aircraft /	Path loss (dB)	g_NodeB Anterma Gain (dBi)	ac_UE EIRP	Max Rx. Power g Node B(dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dB)
3000	48	4.04	112.8	-1.84	23	-96.67	-101.50	-4.63
4000	48	5.38	115.3	-1.84	23	-99.16	-101.50	-2.34
5000	48	6.73	117.3	-1.84	25	-101_10	-101.50	-0.40
6000	48	8.07	118.8	-1.84	23	-102.68	-101.50	1.18
7000	48	9.42	120.2	-1.84	23	104.02	-101.50	2.52
8000	48	10.76	121.3	-1.84	23	105.18	-101.50	3.68
9000	48	12.1	122.4	-1.84	23	-106.20	-101.50	4.70
10000	48	13.45	123.5	-1.84	23	-107.11	-101.50	5.61

Table 36 LTE ac-UE to g-NodeB at 2600MHz

Scenario 3 ac-NCU to g UE/g-MS

Table 37 to Table 53 reviews the connected levels received on the ground in the ac-MS/ac-UE from the NCU. Note the NCU will not operate in the 1800 MHz band over the United States as there in no ground network for the ac-MS/UE to receive, but the table is included for completeness. Note also that the ac-NodeB operates at 12 dB higher power than the ac-NCU at 1880 MHz and 2100 MHz. The process follows the methodology defined in ECC Report taking the received level in Scenario 1, radiation factor as defined in Section 7.5.2 in Report 93,² the medium aircraft attenuation from the aircraft fuselage 10dB from Table 13 in Report 93 to work out the external EIRP and then using the path loss to calculate the noise generated in the g-UE/g-MS and the increase in the g-UE noise floor.

Tables 37 to 53 show what increase in noise floor we would expect to see from the NCU on the aircraft to the g-UE/MS. The ECC decision indicated that a increase of 1dB was the acceptable limit and we can see that for all bands including the USA we are well within this limit, with the potential exception of 800 MHz at 3 Km (increase of 1.3dB). The very conservative worst case assumptions suggest this is not a material issue. Note: GSM numbers are taken directly from ECC Report 93.



LTE 700MHz (USA)

	LTE g-BTS					700M	Hz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wrt
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/10MHz)	(dB)	g_UE (dBm/ch)	(dBm/10MHz)	ref) (dB)
3000	48	4.04	-57.77	62	10	-5.77	101.4	-107.20	-95	0.25
4000	48	5.38	-60.26	62	10	-8.26	103.9	-112.18	-95	0.08
5000	48	6.73	-62.20	62	10	-10.20	105.9	-116.06	-95	0.03
6000	48	8.07	-63.78	62	10	-11.78	107.4	-119.22	-95	0.02
7000	48	9.42	-65.12	62	10	-13.12	108.8	-121.91	-95	0.01
8000	48	10.76	-66.28	62	10	-14.28	109.9	-124.22	-95	0.01
9000	48	12.1	-67.30	62	10	-15.30	111.0	-126.26	-95	0.00
10000	48	13.45	-68.22	62	10	-16.22	111.9	-128.09	-95	0.00

Table 37 ac-NCU to LTE g-UE (700MHz)

800MHz ITU Region 1&3 - USA 800MHz

	GSM					800MHz				
Aircraft height above ground (m)	Worst cere elevation angle (*)	Distance alreaft / base station (km)	Max Rx. Power in aircraft (dBm / ch)	Radiation factor	Aircraft attenuation Foi leaky feeder (dB)	Emovalent EIRF (as pt of source) (d8m/ch)	Path lines (dB)	Maxitx Noise by #_MS (dbm/ch)	system Noise Lauri, ref (val. (d8m/ch)	in Noise Floor at g_MS (wrt ref) (dB)
3000	48	4.04	72.50	63	10	-19.50	102.0	-122.09	-114	0.63
4000	48	5,38	26.90	63	10	-21.90	105.1	-126.98	-114	0.41
5000	88	5.71	-15.70	6.5	10	-25.70	107:0	-130.72	-114	0.09
6000	49	8.97	78.20	61	10	-25.20	108.0	-133.80	-114	6.05
7000	48	9.42	-79.50	63	10	-26.50	109.9	-136.44	-114	0.02
E000	49	10.76	03.0B-	63	10	-27.60	111.1	-138.70	-114	0.01
9000	48	12:1	81.50	63	1.0	-28:50	112.1	-140.62	-114	0.01
10000	48	33.45	83.30	63	10	30.30	113.0	143.34	-214	0.01

Table 38 ac-NCU to GSM g-UE (800MHz)

	UMTS g-UE					800M	Hz			
Nicosit kegin above ground (m)	World beet electrical angle (*)	Distance already /	Max Rx. Flower In aircraft (dBm./ ck)	Kadafor factor	Aircraft attenuation for leaky tender (d8)	Equivalent EIRF (as pt of Source) (48m)(ch)	Path line (68)	Make the Mission for ig UE (dBm/ch)	system Noise Level, ref val (dlim/ch)	Increase in Noise Fluor at g_UE pure ref((dtl))
3006	42	4,04	-68.99	66	38	35.99	101.6	118.58	114	1.30
4000	48	5.38	-71.48	68	.10	-12.45	305.1	-123.55	-214	0.46
5000	48	6.73	73.42	68 68	06	-20.42	107 D	127.44	114	2.19
6000	48	8.07	-75.00	68	100	22.00	108.6	-130.60	-114	0.00
7000	AE	9.42	-76.34	63	30	-23.34	1,09,9	-133.29	-114	8.05
8000	.48	10.76	-77.50	68	10	-24.90	HILI	-135.60	-114	0.03
9000	48	12.1	-78.52	63	10	-25.52	312.1	-137.64	-110	0.02
30000	48	13.45	79.44	63.	10	-25,44	113.0	139.47	-114	0.01

Table 39 ac-NCU to UMTS g-UE (800MHz)

	LTE g-BTS					800M	Hz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wrt
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/10MHz)	(dB)	g_UE (dBm/ch)	(dBm/10MHz)	ref) (dB)
3000	48	4.04	-58.93	63	10	-5.93	102.6	-108.52	-95	0.19
4000	48	5.38	-61.42	63	10	-8.42	105.1	-113.49	-95	0.06
5000	48	6.73	-63.36	63	10	-10.36	107.0	-117.38	-95	0.03
6000	48	8.07	-64.94	63	10	-11.94	108.6	-120.54	-95	0.01
7000	48	9.42	-66.28	63	10	-13.28	109.9	-123.23	-95	0.01
8000	48	10.76	-67.44	63	10	-14.44	111.1	-125.54	-95	0.00
9000	48	12.1	-68.46	63	10	-15.46	112.1	-127.58	-95	0.00
10000	48	13.45	-69.38	63	10	-16.38	113.0	-129.41	-95	0.00

Table 40 ac-NCU to LTE g-UE (800MHz)



900MHz (ITU Region 1&3) + SMR USA

	GSM					900MHz				
Aircraft height above ground (m)	Worst case elevation angle (°)	Distance aircraft / base station (km)	Max Rx. Power in aircraft (dBm / ch)	Radiation factor	Aircraft attenuation for leaky feeder (dB)	Equivalent EIRP (as pt of source) (dBm/ch)	Path loss (dB)	Max Rx Noise by g_MS (dBm/ch)	system Noise Level, ref val. (dBm/ch)	in Noise Floor at g_MS (wrt ref) (dB)
3000	48	4.04	-73.50	64	10	-19.50	103.6	-123.11	-114	0.50
4000	48	5.38	-75.90	64	10	-21.90	106.1	-128.00	-114	0.17
5000	48	6.73	-77.70	64	10	-23.70	108.0	-131.75	-114	0.07
6000	48	8.07	-79.20	64	10	-25.20	109.6	-134.82	-114	0.04
7000	48	9.42	-80.50	64	10	-26.50	111.0	-137.47	-114	0.02
8000	48	10.76	-81.60	64	10	-27.60	112.1	-139.72	-114	0.01
9000	48	12.1	-82.50	64	10	-28.50	113.1	-141.64	-114	0.01
10000	48	13.45	-83.30	64	10	-29.30	114.1	-143.36	-114	0.01

Table 41 ac-NCU to GSM g-UE (900MHz)

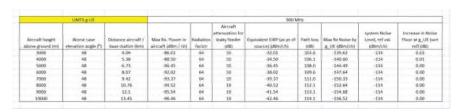


Table 42 ac-NCU to UMTS g-UE (900MHz)



Table 43 ac-NCU to LTE g-UE (900MHz)

1800MHz

Note: NCU will not operate in this band in the USA only the a-Node B (LTE) or the a-BTS (GSM) will be operating but all technologies shown for completeness.



	GSM		1800MHz						NCU			ac-	BTS	
											Equivalent			
Aircraft		Distance	Max Rx.							Increase in	EIRP (as pt	Max Rx		Increase in
height	Worst	aircraft /	Power in		Aircraft			Max Rx	system	Noise Floor	of source)	Noise by	system	Noise Floo
above	case	base	aircraft		attenuation	Equivalent EIRP (as		Noise by	Noise Level,	at g_MS	(dBm/10MH	g_UE	Noise Level,	at g_UE
ground	elevation	station	(dBm /	Radiation	for leaky	pt of source)	Path loss	g_MS	ref val.	(wrt ref)	z) for ac-	(dBm/ch)	ref val.	(wrt ref)
(m)	angle (°)	(km)	ch)	factor	feeder (dB)	(dBm/ch)	(dB)	(dBm/ch)	(dBm/ch)	(dB)	Node	for ac-BTS	(dBm/ch)	(dB)
3000	48	4.04	-81.70	70	10	-21.70	109.6	-131.33	-114	0.08	-11.70	-121.33	-114	0.74
4000	48	5.38	-82.60	70	10	-22.60	112.1	-134.72	-114	0.04	-12.60	-124.72	-114	0.35
5000	48	6.73	-83.50	70	10	-23.50	114.1	-137.57	-114	0.02	-13.50	-127.57	-114	0.19
6000	48	8.07	-84.30	70	10	-24.30	115.6	-139.94	-114	0.01	-14.30	-129.94	-114	0.11
7000	48	9.42	-85.00	70	10	-25.00	117.0	-141.99	-114	0.01	-15.00	-131.99	-114	0.07
8000	48	10.76	-85.60	70	10	-25.60	118.1	-143.74	-114	0.00	-15.60	-133.74	-114	0.05
9000	48	12.1	-86.10	70	10	-26.10	119.2	-145.26	-114	0.00	-16.10	-135.26	-114	0.03
10000	48	13.45	-86.50	70	10	-26.50	120.1	-146.58	-114	0.00	-16.50	-136.58	-114	0.02

Table 44 ac-NCU/ac-NodeB to g-MS (1800MHz)

	LTE g-UE		1800MHz						NCU			ac-No	odeB	
									system					
									Noise					
					Aircraft	Equivalent EIRP			Level, ref	Increase in	Equivalent EIRP	Max Rx Noise		Increase in
					attenuation for	(as pt of source)			val.	Noise Floor at	(as pt of source)	by g_UE	system Noise	Noise Floor at
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	(dBm/10MHz) for	Path loss	Max Rx Noise by	(dBm/10	g_UE (wrt ref)	(dBm/10MHz)	(dBm/ch) for	Level, ref val.	g_UE (wrt ref)
above ground (m)	elevation angle (⁰)	base station (km)	aircraft (dBm / ch)	factor	(dB)	NCU	(dB)	g_UE (dBm/ch)	MHz)	(dB)	for ac-Node	ac-NodeB	(dBm/10MHz)	(dB)
3000	48	4.04	-73.47	70	10	-13.47	109.6	-123.11	-95	0.01	-3.47	-113.11	-95	0.07
4000	48	5.38	-75.96	70	10	-15.96	112.1	-128.08	-95	0.00	-5.96	-118.08	-95	0.02
5000	48	6.73	-77.91	70	10	-17.91	114.1	-131.97	-95	0.00	-7.91	-121.97	-95	0.01
6000	48	8.07	-79.48	70	10	-19.48	115.6	-135.13	-95	0.00	-9.48	-125.13	-95	0.00
7000	48	9.42	-80.83	70	10	-20.83	117.0	-137.81	-95	0.00	-10.83	-127.81	-95	0.00
8000	48	10.76	-81.98	70	10	-21.98	118.1	-140.12	-95	0.00	-11.98	-130.12	-95	0.00
9000	48	12.1	-83.00	70	10	-23.00	119.2	-142.16	-95	0.00	-13.00	-132.16	-95	0.00
10000	48	13.45	-77.92	70	10	-17.92	120.1	-138.00	-95	0.00	-7.92	-128.00	-95	0.00
10000	48	13.45	-77.92	/0	10	-17.92	120.1	-138.00	-95	0.00	-7.92	-128.00	-95	0.00

Table 45 ac-NCU/ac-NodeB to UMTS g-UE (1800MHz)

	UMTS g-UE		1800MHz						NCU			ac-Node	В	
					Aircraft					Increase in	Equivalent EIRP	Max Rx Noise	system	Increase in
					attenuation for				system Noise	Noise Floor at	(as pt of source)	by g_UE	Noise Level,	
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in		leaky feeder	Equivalent EIRP (as pt of		Max Rx Noise by	Level, ref val.		(dBm/10MHz) for			at g_UE (w
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/ch)	(dB)	g_UE (dBm/ch)	(dBm/ch)	(dB)	ac-Node	ac-NodeB	(dBm/ch)	ref) (dB)
3000	48	4.04	-92.03	70	10	-32.03	109.6	-141.67	-114	0.01	-22.03	-131.67	-114	0.07
4000	48	5.38	-94.52	70	10	-34.52	112.1	-146.64	-114	0.00	-24.52	-136.64	-114	0.02
5000	48	6.73	-96,47	70	10	-36,47	114.1	-150.53	-114	0.00	-26.47	-140.53	-114	0.01
6000	48	8.07	-98.04	70	10	-38.04	115.6	-153.69	-114	0.00	-28.04	-143.69	-114	0.00
7000	48	9.42	-99,39	70	10	-39,39	117.0	-156.37	-114	0.00	-29.39	-146.37	-114	0.00
8000	48	10.76	-100.54	70	10	-40.54	118.1	-158.68	-114	0.00	-30.54	-148.68	-114	0.00
9000	48	12.1	-101.56	70	10	-41.56	119.2	-160.72	-114	0.00	-31.56	-150.72	-114	0.00
10000	48	13.45	-102.48	70	10	-42.48	120.1	-162.56	-114	0.00	-32.48	-152.56	-114	0.00

Table 46 ac-NCU/ac-NodeB to LTE g-UE (1800MHz)

1900MHz (PCS + Region 2)

	GSM					1900MHz				u
Aircraft height above ground (m)	Worst rase elevation angle (?)	Distance aircraft / base station (km)	Max Rx. Power in airciaft (dBm / ch)	Radiation factor	Abcraft attenuation for leaky faeder (it8)	Equivalent EIRF (as pt of source) (dRm/ch)	Path loss (dil)	Max Rx Noise by g_MS (dBm/ch)	system Noise Level, ref yel. (ilBm/rtir)	in Noise Florar at g_MS (wrt ref. (dB)
3000	48	4,04	-82.20	71	10	-21.20	110.1	-131.30	-114	0.08
4000	48	5.38	-83.10	71	10	-22.10	112.6	-114.69	-114	15.04
5000	48	6.73	-84.00	71	10	-23.00	114.5	-137.54	-114	0.02
6000	48	8.07	-84.80	71	10	-23.80	116.1	-139.91	-tia	0.01
7000	48	9.42	-85.50	71	10	-24.50	117.5	-141.96	-t14	0.01
8000	48	10.76	-86.10	71	10	-25.10	118.6	-141.71	-114	0.00
9000	48	32.1	-86.60	71	10	-25.60	119.6	-145.23	-114	0.00
10000	48	13.45	-87.00	71	10	-26.00	120.5	+246.55	-t14	0.00

Table 47 ac-NCU to g-BTS (1900MHz)



	UMTS g-UE					1900M	1Hz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wr
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/ch)	(dB)	g_UE (dBm/ch)	(dBm/ch)	ref) (dB)
3000	48	4.04	-92.50	71	10	-31.50	110.1	-141.61	-114	0.01
4000	48	5.38	-94.99	71	10	-33.99	112.6	-146.58	-114	0.00
5000	48	6.73	-96.94	71	10	-35.94	114.5	-150.47	-114	0.00
6000	48	8.07	-98.51	71	10	-37.51	116.1	-153.63	-114	0.00
7000	48	9.42	-99.86	71	10	-38.86	117.5	-156.31	-114	0.00
8000	48	10.76	-101.01	71	10	-40.01	118.6	-158.62	-114	0.00
9000	48	12.1	-102.03	71	10	-41.03	119.6	-160.66	-114	0.00
10000	48	13.45	-102.95	71	10	-41.95	120.5	-162.50	-114	0.00

Table 48 a-NCU to UMTS g-UE (1900MHz)

	LTE g-UE					1900N	1Hz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wr
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/10MHz)	(dB)	g_UE (dBm/ch)	(dBm/10MHz)	ref) (dB)
3000	48	4.04	-73.94	71	10	-12.94	110.1	-123.05	-95	0.01
4000	48	5.38	-76.43	71	10	-15.43	112.6	-128.02	-95	0.00
5000	48	6.73	-78.38	71	10	-17.38	114.5	-131.91	-95	0.00
6000	48	8.07	-79.95	71	10	-18.95	116.1	-135.07	-95	0.00
7000	48	9.42	-81.30	71	10	-20.30	117.5	-137.75	-95	0.00
8000	48	10.76	-82.45	71	10	-21.45	118.6	-140.06	-95	0.00
9000	48	12.1	-83.47	71	10	-22.47	119.6	-142.10	-95	0.00
10000	48	13.45	-78.39	71	10	-17.39	120.5	-137.94	-95	0.00

Table 49 a-NCU to LTE g-UE (1900MHz)

2100MHz (Region 1&3) - AWS/AWS-4

	UMTS g-UE					2100N	ИНZ			
					Aircraft					
					attenuation for				system Noise	Increase in Nois
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (w
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/ch)	(dB)	g_UE (dBm/ch)	(dBm/ch)	ref) (dB)
3000	48	4.04	-93.37	71	10	-32.37	111.0	-143.34	-117	0.01
4000	48	5.38	-95.86	71	10	-34.86	113.5	-148.32	-117	0.00
5000	48	6.73	-97.80	71	10	-36.80	115.4	-152.21	-117	0.00
6000	48	8.07	-99.38	71	10	-38.38	117.0	-155.36	-117	0.00
7000	48	9.42	-100.73	71	10	-39.73	118.3	-158.05	-117	0.00
8000	48	10.76	-101.88	71	10	-40.88	119.5	-160.36	-117	0.00
9000	48	12.1	-102.90	71	10	-41.90	120.5	-162.40	-117	0.00
10000	48	13.45	-103.82	71	10	-42.82	121.4	-164.24	-117	0.00

Table 50 a-NCU to UMTS g-UE (2100MHz)

	LTE g-UE					2100N	MHz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wrt
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/10MHz)	(dB)	g_UE (dBm/ch)	(dBm/10MHz)	ref) (dB)
3000	48	4.04	-74.81	71	10	-13.81	111.0	-124.78	-95	0.00
4000	48	5.38	-77.30	71	10	-16.30	113.5	-129.76	-95	0.00
5000	48	6.73	-79.24	71	10	-18.24	115.4	-133.65	-95	0.00
6000	48	8.07	-80.82	71	10	-19.82	117.0	-136.80	-95	0.00
7000	48	9.42	-82.17	71	10	-21.17	118.3	-139.49	-95	0.00
8000	48	10.76	-83.32	71	10	-22.32	119.5	-141.80	-95	0.00
9000	48	12.1	-84.34	71	10	-23.34	120.5	-143.84	-95	0.00
10000	48	13.45	-79.26	71	10	-18.26	121.4	-139.68	-95	0.00

Table 51 a-NCU to LTE g-UE (2100MHz)

2300MHz (WCS)



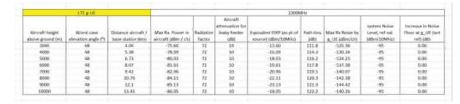


Table 52 a-NCU to LTE g-UE (2300MHz)

2600MHz (USA TDD LTE + Region 1&3)

	LTE g-UE					2600N	MHz			
					Aircraft					
					attenuation for				system Noise	Increase in Noise
Aircraft height	Worst case	Distance aircraft /	Max Rx. Power in	Radiation	leaky feeder	Equivalent EIRP (as pt of	Path loss	Max Rx Noise by	Level, ref val.	Floor at g_UE (wr
above ground (m)	elevation angle (°)	base station (km)	aircraft (dBm / ch)	factor	(dB)	source) (dBm/10MHz)	(dB)	g_UE (dBm/ch)	(dBm/10MHz)	ref) (dB)
3000	48	4.04	-75.60	73	10	-12.60	111.8	-124.36	-95	0.01
4000	48	5.38	-78.09	73	10	-15.09	114.3	-129.34	-95	0.00
5000	48	6.73	-80.03	73	10	-17.03	116.2	-133.23	-95	0.00
6000	48	8.07	-81.61	73	10	-18.61	117.8	-136.38	-95	0.00
7000	48	9.42	-82.96	73	10	-19.96	119.1	-139.07	-95	0.00
8000	48	10.76	-84.11	73	10	-21.11	120.3	-141.38	-95	0.00
9000	48	12.1	-85.13	73	10	-22.13	121.3	-143.42	-95	0.00
10000	48	13.45	-80.05	73	10	-17.05	122.2	-139.26	-95	0.00

Table 53 ac-NCU to LTE g-UE (2600MHz)

US Specific Scenarios A-D

The follow analysis covers the very specific aspects of the ASS using the E-UTRA Band 1 & 3 overflying the USA. Please refer to Figure 2 for Scenario definitions.

USA Scenario A

Error! Reference source not found. This assessment shows that that controlled ac-MS/UEs onboard will not affect the g-UE/MS receiver because there is always a positive margin of at least 4 and 9dB for UMTS and LTE, respectively, at the very lowest altitude. As previously, a negative margin indicates that the g-UE could receive a signal from the on-board NCU/ac-NodeB. Thus, the positive margins demonstrate that the g-UE/MS will not be adversely affected by controlled ac-UE/MS transmissions.



UN	ATS			1	L900MHz		
Aircraft height above ground (m)	Distance aircraft / base station (km)	Path loss (dB)	Antenna Gain (dBi)	ac_UE EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Reference receiver rensitivity (dBm/ch)	Margin
3000	3	107.5	0	-6	-118.52	-114.00	4.52
4000	4	110.0	0	-6	-121.02	-114.00	7.02
5000	5	112.0	0	-6	-122.95	-114.00	8,95
6000	6	113.5	0	~6	-124,54	-114.00	10.54
7000	7	114.9	0	-6	-125.88	-114.00	11.88
8000	8	116.0	0	-6	-127.04	-114.00	13.04
9000	9	117.1	0	-6	-128.06	-114.00	14.06
10000	10	118.0	0	-6	-128.98	-114.00	14.98

Table 54 ac-UE Tx (1920-1980) -> g-UE Rx (1930-1980) Scenario A

L'	TE			1	1900MHz		
Aircraft height	Distance aircraft /	Path loss (dB)	Antenna Gain (dBi)	ac_UE EIRP	Max Rx. Power in aircraft (dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (d8)
3000	3	107.5	0	8	-104.52	-95.00	9.52
4000	4	110.0	α	8	-107.02	-95.00	12.02
5000	5	112.0	0	8	-108.95	-95.00	13.95
6000	6	113.5	0	8	-110.54	-95.00	15.54
7000	7	114.9	0	8	-111.88	-95.00	16.88
8000	8	116.0	0	8	-113.04	-95.00	18.04
9000	9	117.1	0	8	-114.06	-95.00	19.06
10000	10	118.0	0	8	-114.98	-95.00	19.98

Table 55 ac-UE LTE Tx (1920-1980) -> g-UE Rx (1930-1980) Scenario A

The analysis indicates that there is no impact on the terrestrial network for Scenario A.

USA Scenario B

This assessment Error! Reference source not found.Error! Reference source not found.covers the a-NodeB (LTE) /ac-BTS (GSM) transmitting on the aircraft to the g-NodeB/BTS Receiver due to the overlaps of the 1800MHz with the USA bands with negligible increase in the g-BTS/g-Node Noise floor. Note: UMTS added for completeness. For Scenario B, we use the same threshold of 1 dB increase in noise floor to indicate an unacceptable level of interference on the ground network. — NCU powers only.



	GSM						1800N	1Hz				
Aircraft height above ground (m)	Worst rate elevation angle (°)	Distance alreraft / liass station (km)	Max Rx. Power in autraft (dBm / ch)	Radiation	Alleration attenuation for haby feeder (d8)	a BTS Margin above NCU	Equivalent EIRP (as p) of source) (dRm/zh) for a-RTS	Path lace (dB)	g 815 Antenna Gain	Mas Rx Noise by g_BFS (dBm/ch)	system Noise Level, (ef Lat (dBm/ch)	Increase in Noise Floor of R_B15 (wrt ref) (dB)
3000	48	4.04	-81.70	70	10	10	-11.70	109.6	+10.4	-13L73	-114	0.07
4000	48	5.38	-82.60	70	10	to	-1.0.60	112.1	+10.m	-133.12	-114	0.05
5000	48	6.73	-83.50	70	10	10	-11.50	114.1	-10.4	-135.97	-114	0.03
6000	48	8.07	-84.30	70	10	10	-12.30	115.6	-10.4	-138.34	-114	0.02
7000	48	9.42	-85.00	70	10	10	-13.00	117.0	-10.4	-140.39	-114	0.01
8000	48	10.76	85.60	20	10	10	13.60	118,1	10.4	142.14	-114	0.01
9000	48	12.1	-86.10	70	10	10	-14.10	119.2	-10.4	-143.66	114	0.00
10000	48	18.45	-86.50	70	10	to	-14.50	120.1	-10.4	-144.98	1114	0.00

Table 56 ac-BTS to g-BTS 1800MHz

	UMTS						1800MHz									
Aircraft height above ground (m)	Worst rave elevation angle (°)	Distance aircraft / hase station (km)	Max Rx. Power in aurealt (dBm / ch)	Rédiation	Alleratt attenuation for Imaky feeder (d8)	á-Nod≢B Margin	Equivalent EIRP (as pr of source) (dRm/ch) for ac- Node3	Path loss (dB)	g 815 Antenna Gain	Más Rx Naise liy g_BTS (dBm/ch)	system Noise Level, (et val (dBm/ch)	Increase in Noise floor of g_BTS (wrt ref (dB)				
3000	48	4.04	-92.03	70	10	10	-22.03	109.6	+1.84	-133.51	-121	EL24				
4000	48	5.38	-94.52	70	10	10	-24.52	112.1	+1.84	-138.4B	-121	0.08				
5000	48	6.73	-96,47	70	10	10	-26.47	114.1	-1.84	-142.37	-121	0.03				
6000	48	8.07	-98.04	70	10	10	28.04	115.6	1.84	-145.53	-121	0.02				
7000	48	9.42	-99,39	70	10	10	-29.39	117.0	-1.84	-148.21	-121	0.02				
8000	48	10.76	-100.54	70	10	10	-30.54	118,1	-1.84	-150.52	-121	0.00				
9000	48	12.1	-101.56	70	10	10	-31.56	119.2	1.84	-152.56	121	0.00				
10000	48	18.45	-102.48	70	10	10	-32.48	170.1	1.84	-154.40	121	11.00				

Table 57 ac-NodeB to g-NodeB

	LTE						1800N	1Hz				
Aircraft height above ground (m)	Worst rate elevation angle (°)	Distance alveraft / hissa station (km)	Max Rx. Power in autraft (dBm / ch)	Rediation	Allicraft attenuation for leaky feeder (d8)	a-NodeB Margin	Equivalent EIRP (as pt of source) (dBm/ch)	Púth loss (dB)	g 815 Antenna Gain	Max Rx Naise liy g_BFS (dBm/ch)	system Noise Level, (ef Lat (dBm/ch)	Increase in Naise Floor of g_B15 (wrt ref (dB)
3000	48	4.04	-73.47	70	10.	10	-3.47	109.6	+1.84	-114.95	+101.5	0.19
4000	48	5.38	-75.96	70	10	10	-5.96	112.1	+1.84	-119.92	+101.5	0.06
5000	48	6.73	-77.91	70	10	10	-7,91	114.1	-1.84	-123.81	-101.5	0.03
6000	48	8.07	-79,48	70	10	10	-9,48	115.6	1.84	-126.97	-101.5	0.02
7000	48	9.42	-80,83	70	10	10	-10.83	117.0	-1.84	-129.65	-101.5	0.02
8000	48	10.76	-81,98	70	10	10	-11.98	118.1	-1.94	-131.96	-101.5	0.00
9000	48	12.1	-83.00	70	10	10	-13.00	119.2	1.84	-134.00	-101.5	0.00
10000	48	18.45	-83.92	70	10	10	-13.92	120.1	1.84	-135.84	-101.5	11.00

Table 58 ac-NodeB LTE to g-NodeB (LTE)

For Scenario B we can conclude that there is no impact on the terrestrial network.



USA Scenario C

As AeroMobile is not aware of the technologies used in the US Federal band, this assessment strives to calculate the pfd that would be received on the ground measured in 10 MHzError! Reference source not found. This assumes path loss as the height of the aircraft and no attenuation from the aircraft fuselage so it very much worst case.

Scenario C1

Addresses ac-NodeB/BTS TX (operating in the 1805-1880MHz) -> US Fed RX(1805-1850MHz).

G:	SM		1800MH	Z
Aircraft	Distance	Max Rx.		
height	aircraft /	Power in		ac_Node B
above	base	aircraft		pfd on
ground	station	(dBm/	Path loss	ground(dBm/
(m)	(km)	10MHz	(dB)	10MHz)
3000	3	-38.28	107.0	-145.32
4000	4	-39.18	109.5	-148.72
5000	5	-40.08	111.5	-151.56
6000	6	-40.88	113.1	-153.94
7000	7	-41.58	114.4	-155.98
8000	8	-42.18	115.6	-157.74
9000	9	-42.68	116.6	-159.27
10000	10	-43.08	117.5	-160.58

Table 59 ac-BTS GSM TX (operating in the 1805-1880MHz) -> US Fed RX (1805-1850MHz) on Ground (Scenario C.1)

U	MTS		1800MHz	
Aircraft height above ground (m)	Distance aircraft / base station (km)	Equivalent EIRP (as pt of source) (dBm/10MHs)	Path Iosa (d8)	at_Node B pfd on ground(dBm /10MHz)
3000	3	-36.19	107.0	-143,24
4000	4	-38.68	109.5	-148.22
5000	5	-40.62	111.5	-152-11
6000	6	42.20	113.1	-155.27
7000	7	-43.54	114.4	-157.95
8000	8	-44.70	115.6	-160.27
9000	9	-45.72	116.6	-162.31
10000	10	-46.64	117.5	-164.14

Table 60 ac-NodeB UMTS TX (operating in the 1805-1880MHz) -> US Fed RX(1805-1850MHz) on Ground (Scenario C.1)



E E	TE		1800MH	łz.
Aircraft height above ground (m)	Distance aircraft / hase station (km)	Max Rx. Power in aircraft (dBm / ch)	Path loss (dB)	ac_Node B pfd on ground(dBm/ 10MHz)
3000	3	-13.47	107,0	-120.52
4000	4	-15.96	109.5	-125.51
5000	5	-17.91	111.5	-129.39
6000	6	-19.48	113.1	-132,55
7000	7	-20.83	114.4	-135.23
8000	8	-21.98	115.6	-137.55
9000	9	-23,00	116.6	-139.59
10000	10	-17.92	117.5	-135.43

Table 61 ac-NodeB LTE TX (operating in the 1805-1880MHz) -> US Fed RX(1805-1850MHz) PFD on Ground (Scenario C.1)

Scenario C2

Addresses ac-UE/MS TX (operating in the 1755-1785MHz) -> US Fed RX (1755-1785MHz). Note: Added UMTS for completeness.

G	SM		1700MHz	
Aircraft height above ground (m)	Distance aircraft / base station (km)	Path loss	ac_UE EIRP (dBm)	ac_MS pfd on ground(dBm /10MHz)
3000	3	106.5	U	-128.13
4000	4	109.1	0	-130.63
5000	5	111.0	D	-132.56
6000	6	112.6	D	-134.15
7000	7	113.9	D	-135.49
8000	8	115.1	0	-136,65
9000	9	116.1	0	-137.67
10000	10	117.0	0	-138.58

Table 62 ac-MS GSM TX (operating in the 1755-1785MHz) -> US Fed RX (1755-1785MHz) PFD (Scenario C.2)



UI	VITS		1700MHz	
Aircraft height above ground	Distance aircraft / base station	Path loss (dB)	Reference receiver sensitivity (dBm/ch)	ac_UE pfd on ground(dBm /10MHz)
3000	3	106.6	-6.00	-116.71
4000	4	109.1	-6.00	-119.21
5000	5	111.5	-6.00	-121.64
6000	6	113.1	-6.00	-123.23
7000	7	114.4	-6.00	-124.56
8000	8	115.6	-6.00	-125.72
9000	9	116.6	-6.00	-126.75
10000	10	117.5	-6.00	-127.66

Table 63 ac-UE UMTS TX (operating in the 1755-1785MHz) -> US Fed RX (1755-1785MHz) PFD (Scenario C.2)

LTE		1700MHz			
Aircraft height above ground	Distance aircraft / base station	Path loss (dB)	ac_UE EIRP (dBm)	ac_UE pfd on ground(dBm/10M Hz)	
3000	3	106.6	8	-106.56	
4000	4	109,1	8	-109.06	
5000	5	111.0	8	-111.00	
6000	6	112.6	8	-112.58	
7000	7	113.9	8	-113,92	
8000	8	115.1	8	-115.08	
9000	9	116.1	8	-116.10	
10000	10	117.0	8	-117.02	

Table 64 ac-UE/MS LTE TX (operating in the 1755-1785MHz) -> US Fed RX (1755-1785MHz) PDF (Scenario C.2)

Scenario D

Scenario D is similar to Scenario 2 in that it involves the ac-UE/MS to g-NodeB case, but involves controlled rather than uncontrolled transmissions from ac-UE/MS devices.

UMTS		1700MHz a-UE						
Aircraft height above ground (m)	Distance aircraft / base station (km)	Path loss (dB)	Antenna Gain (dBi)	ac_UE EIRP	Max Rx. Power in aircraft (dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)	
3000	3	106.6	0	-6	-117.55	-114.00	3.55	
4000	4	109.1	0	-6	-120.05	-114.00	6.05	
5000	5	111.0	0	-6	-121.99	-114.00	7.99	
6000	6	112.6	0	-6	-123.57	-114.00	9.57	
7000	7	113.9	0	-6	-124.91	-114.00	10.91	
8000	8	115.1	0	-6	-126.07	-114.00	12.07	
9000	9	116.1	0	-6	-127.09	-114.00	13.09	
10000	10	117.0	0	-6	-128.01	-114.00	14.01	

Table 65 ac-UE (UMTS) to g-Node B (ac-UE Controlled Power)



U	1700MHz a-UE						
Aircraft height above ground (m)	Distance aircraft / base station (km)	Path loss (dB)	Antenna Gain (dBi)	ac_UE EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margir (dB)
3000	3	106.6	0	8	-103.55	-95.00	8.55
4000	4	109.1	0	8	-106.05	-95.00	11.05
5000	5	111.0	0	8	-107.99	-95.00	12.99
6000	6	112.6	0	8	-109.57	-95.00	14.57
7000	7	113.9	0	8	-110.91	-95.00	15.91
8000	8	115.1	0	8	-112.07	-95.00	17.07
9000	9	116.1	0	8	-113.09	-95.00	18.09
10000	10	117.0	0	8	-114.01	-95.00	19.01

Table 66 ac-UE (LTE) to g-NodeB (ac-UE Controlled Power)

GSM		1700MHz a-MS							
Aircraft height above ground (m)	Distance aircraft / base station (km)	Path loss (dB)	Antenna Gain (dBi)	ac_MS EIRP (dBm)	Max Rx. Power in aircraft (dBm / ch)	Reference receiver sensitivity (dBm/ch)	Margin (dB)		
3000	3	106.6	0	0	-111.55	-102.00	9.55		
4000	4	109.1	0	0	-114.05	-102.00	12.05		
5000	5	111.0	0	0	-115.99	-102.00	13.99		
6000	6	112.6	0	0	-117.57	-102.00	15.57		
7000	7	113.9	0	0	-118.91	-102.00	16.91		
8000	8	115.1	0	0	-120.07	-102.00	18.07		
9000	9	116.1	0	0	-121.09	-102.00	19.09		
10000	10	117.0	0	0	-122.01	-102.00	20.01		

Table 67 ac-MS (GSM) to g-BTS (ac-MS Controlled Power)

Conclusions

ECC Report 93 (2006) for GSM onboard was produced in the 2003-2006 time frame with the participation from operators, regulators, equipment manufactures and industry experts. The methodology used in this work formed the foundation for ECC Report 93 (2008) addressing newer frequency bands required for the NCU and later ECC Report 48/187 for LTE and 3G connectivity.

The analysis set forth in this document, which is based on prior ECC approaches, has examined additional NCU control bands to be used in the USA and demonstrated that only modest adjustments would need to be made (e.g., differences due to propagation path losses reduced by 1.1dB from the 800MHz to the USA 700MHz LTE and increased by approx 0.5dB from the 1800MHz to 1900MHz) to enable application of existing approach to AAS operations in the United States.

AeroMobile submits this report as supporting evidence that operation in the existing E-UTRA Band 3 (for GSM/UMTS and LTE) and E-UTRA Band 1 (for LTE and UMTS) would not interfere with any ground mobile network in the United States. Calculation of the pfd in the USA Federal band has also been completed. AeroMobile will work with the appropriate USG authorities to assess whether this pfd would cause any issues for government operations in the band.



References:

- ECC/DEC/(06)07- ECC Decision of 1 December 2006 on the harmonised use of airborne GSM systems in the frequency bands 1710-1785 and 1805-1880 MHz.
- ECC Report 93 compatibility between GSM equipment on-board aircraft and terrestrial networks - Revised 2007.
- 3. ECC Report 187 Compatibility study between mobile communications services on-board aircraft (MCA) and Ground based systems January 2013.
- CEPT Report 48 Report from CEPT to the European Commission in response to the Second Mandate to CEPT on mobile communication services on board aircraft (MCA) - 8th March 2013.
- ITU-R M.2039-2 Characteristics of terrestrial IMT-2000 systems for frequency sharing / interference analysis - Nov 2010
- TS 136 104 Evolved Universal Terrestrial Radio Access (E-UTRA) Base Stations (VS) radio transmission and reception - Release 10.
- 7. TS 136.101 TS 136 104 Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE) radio transmission and reception Release 10.
- 8. ITU-R F.1336-2 Reference radiation patterns of omni-directional, sectoral and other antennas in point to multipoint .
- 9. GSM and UMTS Parameters from ECC Report 93 Table 10 and 11